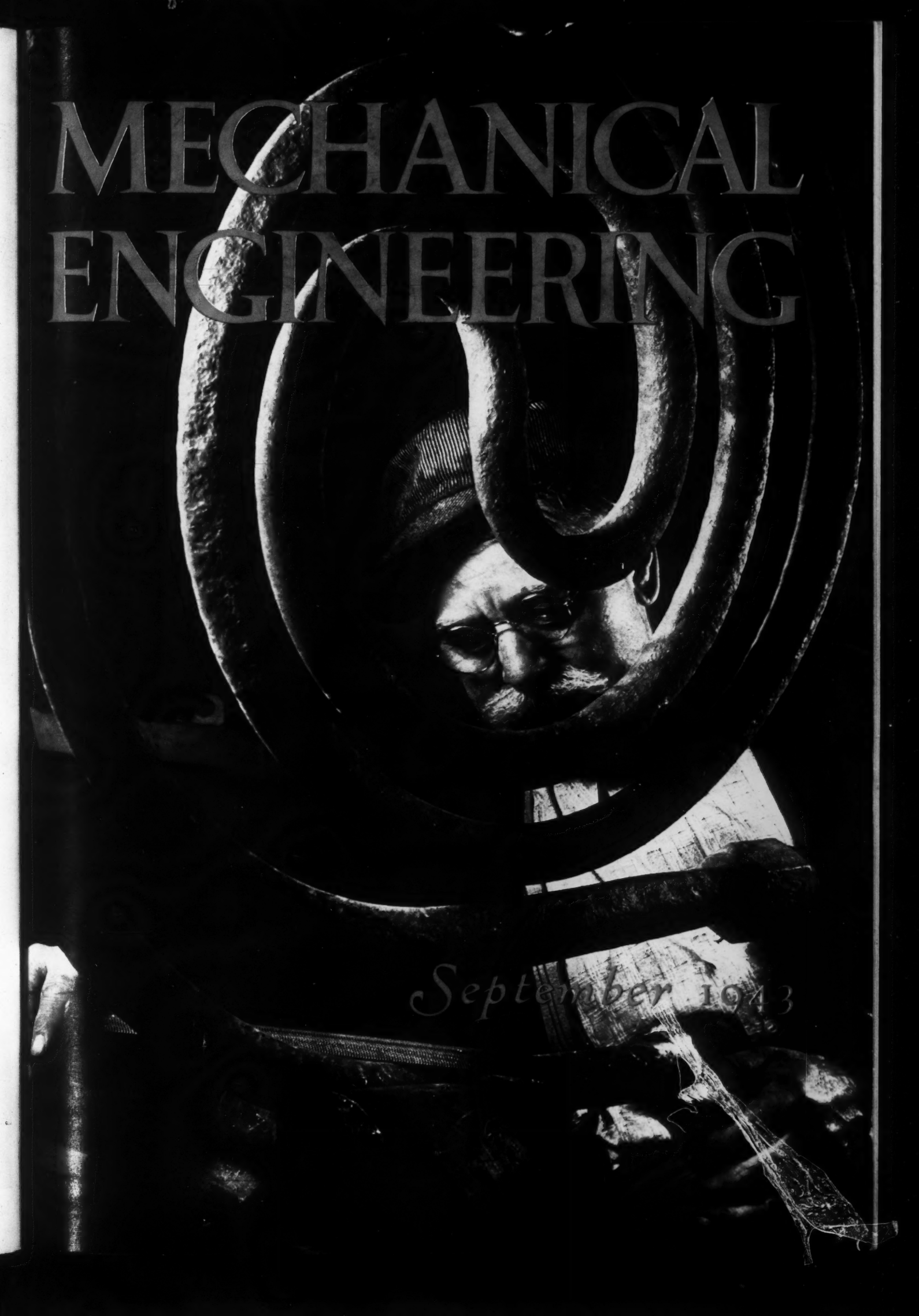
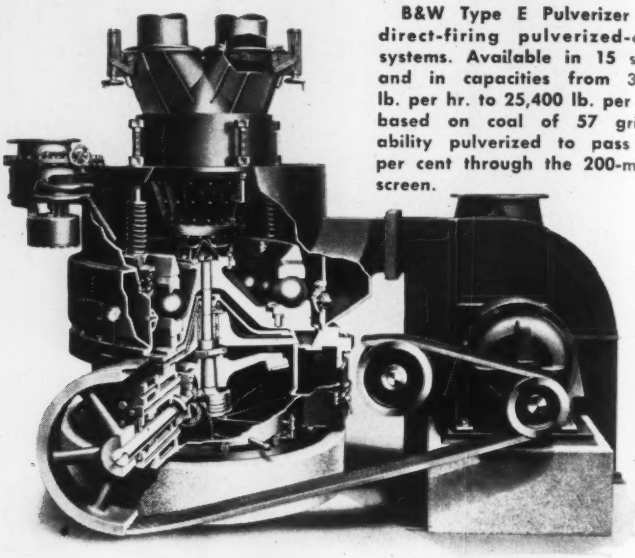

MECHANICAL
ENGINEERING
September 1943

For OIL Conservation and Economy– during Fuel Emergency and Afterward PULVERIZED-COAL FIRING



B&W Type E Pulverizer for direct-firing pulverized-coal systems. Available in 15 sizes and in capacities from 3100 lb. per hr. to 25,400 lb. per hr., based on coal of 57 grindability pulverized to pass 65 per cent through the 200-mesh screen.

If you are burning oil in your boiler furnaces and are planning to convert to coal firing, either through necessity or for economic reasons, now is not too soon to consider the fuel-burning system to employ—not merely as a temporary expedient in the case of forced conversion, or as a stand-by, but for permanent installation. Such a conversion would not only be in the desirable direction of helping save oil for the future and for highly specialized uses in the interest of the national welfare but also would reduce your fuel cost in the face of advanced oil price due to shortage.

The B&W Direct-Firing Pulverized-Coal System with Type E Pulverizer is a profitable investment for such conversion. It is a fully co-ordinated system, from raw-coal bin to burners. It affords the most flexible and efficient means of burning coals of a wide variety, permitting the utilization of those that are most readily obtainable. This system reliably handles coal of a wide range of grindability and surface moisture content, and maintains capacity and fineness throughout the life of the pulverizer grinding-elements. Furthermore, this system is easily and safely operated, with pulverizer output controlled at one point—the primary-air damper—and the coal feed is automatically varied according to air flow, by the feeder controller.

The Type E Pulverizer is a sturdy unit with ball-bearing grinding element of materials that give the utmost in service, considering the nature of the materials handled.

And B&W experience with pulverized-coal firing, which dates back to its early use for firing cement kilns, further suggests investigation of the B&W Direct-Firing System for your boilers.

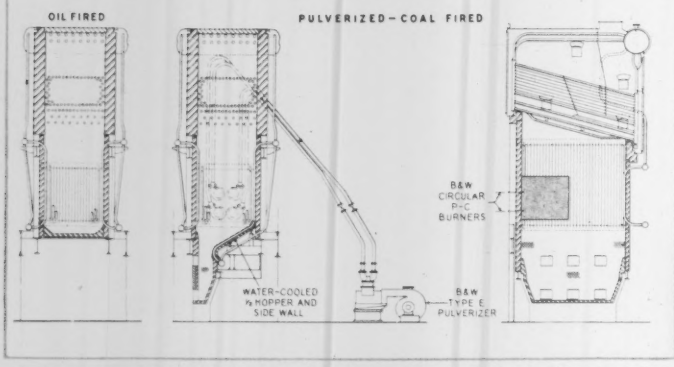
TYPICAL CONVERSIONS

Furnaces converted from oil firing to pulverized-coal firing vary considerably in the changes necessary. Cases in which a reduction in boiler capacity is permissible and increased furnace volume and water cooling are unnecessary, require minimum critical material.

The typical case shown below already had considerable water cooling. By converting straight water-cooled side walls to half hoppers along the length of the two boilers to provide ash pits, it was possible to maintain the minimum permissible capacity of 50,000 lb. steam per hr. Two type E Pulverizers were readily applied to serve B&W Circular Burners installed in the refractory front walls.

Other cases in which no reduction in boiler capacity is permissible may require more extensive alterations, particularly if additional furnace volume is required and modifications of, or additions to, existing water cooling are necessary.

B & W Integral-Furnace Boilers, being designed for multi-fuel firing, have been readily converted merely by the installation of the coal handling and pulverizing equipment, no other changes being necessary.



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MECHANICAL ENGINEERING

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VOLUME 65 NUMBER 9

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Goodyear Aircraft Corporation

Setting Explosive Rivets With Electrically Heated "Gun"

VOLUME 65
No. 9

MECHANICAL ENGINEERING

SEPTEMBER
1943

GEORGE A. STETSON, *Editor*

James A. Seymour

JAMES A. SEYMOUR, who died on June 28, must be listed as one of the great designers and builders of steam engines. He began his engineering career a few months after graduation from the Sheffield Scientific School of Yale University in 1885 when he and John E. McIntosh established the firm of McIntosh and Seymour. At that time Mr. Seymour was taking a postgraduate course at Yale. This was in the early days of the electric-light industry and steam engines were being adapted to, and designed for, the driving of dynamos and generators. In providing steam engines for this service Mr. Seymour placed his company in the front of the steam-engine industry with prime movers of large size, fine workmanship, and high economy.

With the advent of the steam turbine, the steam engine faced a competitor which has since supplanted it as a central-station prime mover. Designing skill of high quality based on mature experience had been lavished on the steam engine. Even as late as 1908 three of Mr. Seymour's engines were installed in the Redondo plant of the Pacific Light and Power Company, near Los Angeles, Calif. Their economy record, reported in a paper by C. R. Weymouth in the A.S.M.E. Transactions of that year, was notable. After a 15-day test the three 5000-kw McIntosh and Seymour "double horizontal and vertical, compound, condensing, automatic, gridiron-valve" engines, size 34 and 70 × 56 in., direct-connected to alternators and running at 100 rpm, showed a performance which led Mr. Weymouth to say that, to the best of his knowledge, "the best turbine performance on the Pacific Coast based on oil fuel is considerably under that found for the Redondo plant." He concluded that the performance was noteworthy "and warrants on the part of designing engineers a far more careful and thorough investigation as to the capabilities of steam engines, when used as prime movers, than is manifest in the practice of late years." Yet these same engines were destined to be among the last of their race.

With the disappearance of the large steam engine from the central station, Mr. Seymour turned his attention to the manufacture of Diesel engines, after having rejected a tempting offer to use his plant for the manufacture of steam turbines for one of today's most prominent builders. In this new field he won a gold medal at the Panama-Pacific International Exposition of 1915 at San Francisco.

Albert Kingsbury

IN 1940, when Mr. Seymour was made an honorary member of The American Society of Mechanical Engineers, Mr. Kingsbury, inventor of the Kingsbury thrust bearing, who died July 28, was similarly honored. Graduated from Cornell University in 1889, Mr. Kingsbury taught engineering subjects at New Hampshire College and Worcester Polytechnic Institute until 1903 when he became associated with the Westinghouse Electric and Manufacturing Company. In 1910 he became a consulting engineer and devoted his time to the development of his invention, the Kingsbury thrust bearing, which was of new and unusual design and has become widely known and used. He founded the Kingsbury Machine Works in 1918.

Great inventions like the thrust bearing of Kingsbury are frequently developed simultaneously and independently in different parts of the globe. Thus while Kingsbury was at work on his invention in the United States, A. G. M. Michell was developing a similar bearing in Australia. When Mr. Michell addressed The American Society of Mechanical Engineers in 1929, on "Progress in Fluid-Film Lubrication," he took pains to pay a magnanimous tribute to Mr. Kingsbury. He said: "In this connection the author avails himself of the opportunity to explain that the pivoted thrust bearings known in America and Europe, respectively, as the 'Kingsbury' and 'Michell' bearings are in principle the same, and to state that the development of these bearings was effected in its early stages by Professor Kingsbury and himself independently in their respective countries without knowledge of each other's work. Professor Kingsbury's work was commenced a few years earlier, though his first publication on the subject was later than the author's. The author also takes the occasion to note the improper omission of Professor Kingsbury's name in some recent European publications, in which are described not only the principle of the bearing but actual constructions effected by the latter and his associates." In spite of Mr. Michell's public statement, only recently publications in Great Britain failed to accord Mr. Kingsbury the credit his illustrious fellow engineer so generously granted.

It is a real distinction for an engineer to develop, as Mr. Kingsbury did, a fundamental scientific principle, like that upon which the pivoted thrust bearing is based, and also to establish an enterprise for the manufacture of a product in which the principle is applied.

Conrad N. Lauer

WHILE Mr. Seymour and Mr. Kingsbury made contributions in the field of design and machine construction, Mr. Lauer, industrial engineer and public-utility executive, who died on August 2, exerted a powerful influence in those phases of engineering which are concerned with the management of industrial enter-

prises. His first employment was with the Link Belt Company which became, under the influence of James Mapes Dodge and the men who worked with him, one of the first to put Taylor's principles of management into effect. It is easy to imagine that a man of Mr. Lauer's forward-looking intelligence and capacity for administration must have been profoundly influenced by the exciting and controversial events which were precipitated by the Taylor System. While at Link Belt Mr. Lauer was sent to the Bethlehem Steel Company to secure data, and later he assisted in introducing scientific-management methods in the Link Belt plant.

With the organization, in 1902, of the firm of Dodge and Day (Kern Dodge, son of James Mapes Dodge, and Charles Day, who later was one of a committee of three appointed by Secretary of the Navy Meyer to report on a plan for introducing scientific management into the Navy), Mr. Lauer became identified with it as an industrial engineer. When the firm was incorporated in 1916 as Day and Zimmerman, Inc., he was made treasurer, general manager, and director, and, later, vice-president. His work involved selection and layout of industrial equipment, routing of materials, determination of types of building structure best suited to the enterprise in question, and investigations for banking interests. In 1929 he became president of the Philadelphia Gas Works, a position he held until a little more than a year ago, when he resigned because of ill health. As director of numerous companies, member of the Board of Managers, Beneficial Saving Fund Society, Trustee of Stevens Institute of Technology, and in other posts in industrial, civic, philanthropic, engineering, and educational organizations, he allowed his interests and talents to range widely.

In addition to his services to The American Society of Mechanical Engineers as its president in 1932, Mr. Lauer's chairmanship of the Society's Committee on Economic Status of the Engineer will long be remembered. Out of this committee's activities came the report on the earnings of mechanical engineers and later the Engineers' Council for Professional Development, one of the most significant influences that has ever been exerted within the engineering profession. His deep concern for the profession and for the principle, preached by such of his early associates as Henry L. Gantt, that the engineer should interest himself and exercise his talents in civic services, led Mr. Lauer to institute, in 1929, the Hoover Gold Medal, to commemorate the civic and humanitarian achievements of engineers. For those qualities which led him to become the focal point for the organization of the E.C.P.D. and that inspired him to institute the Hoover Medal in commemoration of the humanitarian services of engineers, Mr. Lauer's name will long be remembered.

Index a Time-Saver

IN 1941 The American Society of Mechanical Engineers issued a comprehensive "Sixty-Year Index" of all A.S.M.E. technical papers published from 1880 to 1939. Although two general indexes to the Transactions had been published previously, one in 1880 and the other in 1924, the most recent index was planned to include not only the technical papers published in Transactions but also those which appeared in the Proceedings, the *Journal*, MECHANICAL ENGINEERING, and the *Journal of Applied Mechanics*. In this index, which may appropriately be called a "finding list," references are arranged in two lists, one a subject and the other an author index. Because of the comprehensiveness of the scope of the index and the care with which it was compiled, any technical paper can be readily located by means of it. Under each subject heading the arrangement of references is chronological, a feature of great value to the busy engineer. Subject headings are liberally cross-indexed. Up to date, no errors or failures to locate technical papers known to have been published in the periodicals indexed have been reported.

The days that lie ahead of engineers are likely to present many cases where talents, long employed in now familiar fields, will have to be directed into new ones. Reconversion of plants, now engaged principally in war work, to the manufacture of products, some of which will be entirely new, will demand great versatility on the part of engineers and designers. On such occasions the engineer who has formed the habit of consulting convenient references to the literature, such as the A.S.M.E. "Sixty-Year Index," will have found a valuable time-saver.

It is not practicable to publish annually a cumulative index as complete and as comprehensive as the "Sixty-Year Index." The next best substitute is the index to Transactions, *Journal of Applied Mechanics*, and MECHANICAL ENGINEERING issued every January by the A.S.M.E. in the "Society Records" supplement to the Transactions. With these indexes there are included lists of special A.S.M.E. publications issued during the year, a complete list of current publications developed by the technical committees, such as standards, the boiler, power-test, and safety codes, research reports, and bibliographies, the A.S.M.E. biographies, and books on special subjects. Thus the Society attempts to provide every member annually with information on its current publications. If these annual indexes are used with the "Sixty-Year Index," the A.S.M.E. member has at his fingertips the means of finding any technical paper, past or current, published by the Society.

Industry-Ordnance Team

THE generous words of praise and encouragement that General Campbell has issued in his tribute to the "Industry-Ordnance Team," page 638 of this issue, will be appreciated by thousands of engineers and industrial workers on the home front.

General Campbell has hit upon a suggestive word. A team demands team play. Team play can be made effective or futile by the failure of individual players to work together as a team. A brilliantly conceived play may be lost by the stupidity of one of the less important players. Prodigious efforts of human strength and skill may not save a play if the wrong signals have been called. For a team includes all the players. It wins and it loses as a team.

General Campbell's pat on the back will put renewed determination to win into every member of the team.

Some Aspects of DIESEL ENGINES *for* NAVY MAIN PROPULSION

By EARLE W. MILLS

REAR ADMIRAL, ASSISTANT CHIEF, BUREAU OF SHIPS, U.S.N., WASHINGTON, D. C.

YOUR Navy operates one of the largest engineering establishments in the world and although "main propulsion" is usually interpreted to mean the motive power of a ship, it can be construed to cover everything from the smallest ship's boat with a single 25-hp Diesel engine to the mighty new battleships of the *Iowa* class with over 200,000 developed shp divided between four main turbine installations. Included in the range between these extremes are humble tugs, sleek destroyers, silent submarines, dashing cruisers, sturdy aircraft carriers with their stinging swarms of fighter, bomber, and torpedo planes, daring submarine-hunting escort vessels, dozens of auxiliary vessels which are the work horses of the fleet, and literally thousands of all types of landing craft, which, like the ubiquitous Army jeep, we have with us in all places at all times. All of these types put together constitute the Nation's Fleet. They do not operate in company but are widely scattered over the oceans of the world and groups of several types may be formed for a specific mission in which case they are known and operate as "task forces." This great Fleet is still not large enough to serve and cover the eight fronts recently mentioned by Secretary of the Navy Knox, and new ships which constantly incorporate improvements derived from the bitter lessons of war are being added daily by every means which our national economy and resources will permit.

None of these vessels which compose the Fleet is useful or effective unless powered by reliable engines and auxiliaries to drive it against the enemy. This machinery must be operated by capable crews and that problem is not the least of the difficulties which confront the Navy at the present time when we consider that to man only the escort vessels now under contract will require more officers and men than were in the entire Navy when this war started in 1939. However, it is gratifying to be able to state that good progress is being made with personnel requirements; the fact that this success is possible is a tribute to the adaptability and ingenuity of our American boys. The Navy is a complex technical organization but the experience and familiarity our young men have had with automobiles, trucks, tractors, and locomotives are quickly converted to training in Diesel engines, steam turbines, and gasoline aircraft motors.

With regard to this manpower problem it is well known that the Diesel-engine manufacturing branch of American industry has also contributed greatly to our solution by supplying skilled men who have become the nucleus of our training programs. However, the greater contribution of the Diesel industry has been the production of suitable engines and equipment to power the ships mentioned. It is our job to decide what types of available engines we want but it is the ingenuity, the resources, the engineering brains, and the productive skill of this industry which produce the power plants in quantities that have not yet reached their peak.

RECORD OF DIESEL DEVELOPMENT FOR THE NAVY

The development and application of the Diesel engine in the Navy to its many uses is a remarkable achievement. Vice-Admiral S. M. Robinson, who must be credited with many other improvements in naval machinery, gave much of the impetus which started this phenomenal growth; but to many sterling and enthusiastic men in the Diesel industry, who believed in their product and the future of the Diesel, must go the major credit and praise for carrying their plans and conceptions through to a successful realization.

At the close of the first world war we had some 150,000 hp of Diesel engines installed in submarines. Many of these engines were liabilities rather than assets and in 1932 we started to do something about it by encouraging the development of high-speed Diesel engines. We had our aches and pains in the process and I know that the Diesel industry suffered with us. There are today more than 12,000,000 hp installed in a wide variety of ships and applications and the end is not in sight.

Concurrently with the development of new Diesel engines weighing about 16 lb per hp for our submarines, the Navy encouraged and sponsored the development of a line of small high-speed Diesel engines for our ships' boats. This development was made to reduce radically the fire hazard existing in our gasoline-engine-driven boats, to increase the reliability of such engines, and to realize increased power. All objectives were attained and the shift-over of all existing boats in the fleet from gasoline to Diesel engines was no mean feat when it is considered that it was accomplished while bringing in other boats with Diesel engines, to meet the requirements of the new Navy started by President Roosevelt in 1933. The developments of the Diesel boat engine and the improved submarine ngine were but the key logs in a jam that started to clear with a rush when these new engines proved to be successful.

It may be said with propriety that the experience gained in the development of the new submarine engine contributed much to the present-day Diesel-electric locomotive and Diesel tugs while the high-speed Diesel boat engines encouraged many additional applications for such Diesel motors in civilian life.

When the design of our modern submarines was established we were faced with the necessity of practically doubling the power for the same hull, and the lighter higher-speed engine came into its own. By the use of electric drive (direct current to meet the military characteristics required) as many as forty pistons have been applied to drive each propeller. The many daring exploits of our submarines in enemy waters, often 4000 to 5000 miles from home bases, have testified eloquently to the reliable performance obtained from our Diesel-electric propulsion in this silent and efficient arm of our Navy.

With the impetus to Diesel-engine drive resulting from highly successful operation in our submarines and small boats the application of this power has been widely extended in the Navy. Diesel engines are being used to drive tugs with from 400 to 3000 hp depending upon size and type, at least six types of landing craft varying from 175 to 2000 hp, seaplane tenders with 6000 hp, submarine chasers with 800 to 1800 hp, patrol craft and minesweepers with 3000 hp, auxiliary ships and tenders up to 12,000 hp, and escort vessels from 6000 to 12,000 hp.

This Diesel power has been applied in nearly every fashion. We use direct drive even up to 3000 rpm in small boats, simple

Address presented at the National Meeting of the Oil and Gas Power Division, Baltimore Md., June 14–16, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

gear and transmission reductions of $1^1/_2$ and 2 to 1 in other small craft and landing barges, gear drives in some vessels with both single and multiple engines, and multiple-engine drive with electric propulsion in either direct-current or alternating-current power in other types of ships. There are a few composite drives, a combination of geared Diesels and Diesel electric on the same shaft, but the present trend in electric drive is a straight development in electric transmission, using either alternating current or direct current, depending upon the military characteristics required.

Our experience to date with multiple-Diesel direct-current drive has been entirely satisfactory and with reasonable care commutation difficulties have been entirely eliminated. Of course, the Navy has had long satisfactory experience with the conventional turboelectric alternating-current drive; but our experience with multiple Diesel-electric alternating-current propulsion is comparatively new and has been most gratifying. This application of electric power involves running alternating-current Diesel generators in parallel on the same motor or shaft either ahead or in reverse and the problem of satisfactory control has been adequately solved. The maximum number of Diesel generators so far employed on a single shaft has been four. We have designs for twelve such machines on a single motor and this arrangement has been most interestingly demonstrated in a 1/10 power setup complete with controls. This application has merit in regard to flexibility. It permits the same size Diesel engine to be used in plants to produce 2, 4, 8, or 12 times its power, thus providing for mass production of standardized power units. This multiple drive also permits high fuel economy over the entire power range.

WELDED-STEEL CONSTRUCTION AN IMPORTANT NAVY CONTRIBUTION

One of the most important contributions of the Navy to the development of the high-speed Diesel engine was its firm insistence on welded-steel construction. The art of welding was in its infancy when the decision had to be made. Later incidents of war replete with the phenomena of shock have testified to the wisdom of the decision. This development was not without headaches and uneasiness, such, for instance, as followed the discovery of a great number of cracks in several large engine frames of the same type after a most successful performance of over 2 years. In this case the enthusiasm and persistence of those great pioneers of welding brought out on the next attempt a design in all respects sound and acceptable.

Welding, as no other known art, has progressed most consistently on the premise that one learns most from his mistakes. I feel that today we are sure of the fundamentals of welding and that out of welded steel, we can produce quickly and with certainty very light structures for the Diesel engine. When war broke out in Europe, and mines, torpedoes, and bombs began to assail the ships of our allies, providing thereby a most realistic proving ground to show the weaknesses of their equipment, the wisdom of selecting a welded-steel structure for our new Diesel engines could no longer be questioned. Bitter experience has proved that because of its large elongation under stress, steel is the only readily available material that can resist successfully the shocks imposed by war. The welding fraternity deserves the Navy's salute!

PROVIDING SPARE PARTS FOR DIESELS THROUGHOUT THE WORLD

The most widely discussed subject in connection with Diesel engines today is "spare parts." The operation and maintenance of such vast numbers of engines by the Navy all over the globe presents a serious problem of providing spare parts for them. It was soon discovered that a too-ambitious spare parts program would interfere with the production of new engines and two things had to be done: (1) the delivery of spares had to be reduced, and (2) the demand for spares lessened by sending competent trouble shooters into the field to educate the operating personnel in the vital need for conserving spare parts. The two following approaches to relief offer fairly quick returns:

1 Salvage centers are being established in conjunction with distribution centers. The operating personnel at such centers are being taught to salvage from engines damaged beyond repair or stranded.

2 Training courses have been established at the various Diesel-engine schools. In most of these courses emphasis has been placed on training the student how physically to replace worn parts. Seldom has he been shown real examples of worn parts that must be replaced and the real examples of worn parts that should not be replaced. We must instill in these students the burning need for conservation of spare parts and give them the will and confidence to use wearing parts until further use will impair the safe operation of the engine.

PRACTICE OF OVERRATING ENGINES

Another point which most emphatically calls for an answer is a psychological one. Briefly, why does the Diesel-engine industry, in almost every case involved in main propulsion for ships, large or small, tend to overrate its engines? The most serious disservice which the Diesel industry can render to itself is to insist on this overrating. For continuous-duty operation in the Navy, most of our Diesel engines in service should be rated at approximately 80 per cent of the manufacturers' name-plate rating.

This tendency to overrate undoubtedly persists from the initial desire to have the Diesel engine show up well in competition with steam on the basis of weight per horsepower. Also, a considerable factor of carelessness with reference to types has grown up by calling a certain engine a 225-hp unit when, in fact, it is a continuous-duty 175-hp product, and by referring to other engines as 1800-hp units when they are, in fact, good for probably 1400 or 1500 hp on a basis of continuous rating.

There is no rating which is useful to propeller service in the Navy except the continuous-duty rating. It is nothing unusual, particularly under wartime-service conditions, for a ship to be called upon to run at its designed top speed for as long as 2 or 3 days. Manifestly, the captains of the ships expect that their plants can develop the full name-plate horsepower for such period of time as the fuel supply will permit. They have been trained in this belief because many of them have only had experience with steam plants, and this feature is a definite characteristic of such plants. If the boiler power is available, there is in every steam plant an inherent reserve due to the characteristics of steam in so far as the engine is designed to permit passage of steam in excess of the full power rating. There is no such inherent characteristic in the Diesel engine, unless the reserve is built into the engine and is insured by a conservative continuous-duty rating.

The point is best expressed by the requirement that if we desire a Diesel engine with a top emergency rating of 2000 hp, and we desire that engine to deliver 1500 hp to the propeller shaft for continuous duty, we should consider such engine to be only a 1500-hp engine. We should have built into it the fundamental capacity to develop up to 2000 hp in emergencies if we require such power. However, in this case, we should not refer to the rating of the engine as 2000 but we should consider it as a 1500-hp engine. For marine service, either in the Navy or elsewhere, I am strongly of the opinion that the only rating attached to an engine should be its continuous-duty rating. The Diesel-engine industry should give sincere consideration to this point in an endeavor to fit engines to a job that they are qualified to perform and to insure operation with the same factor of reserve power that we have been led to expect from steam plants. This single factor, in my opinion, will remove the temptation of commanding officers to take excessive power out of their engines, reduce their reliabil-

ity, shorten their life, and increase the maintenance costs; or, in short, give a good product a bad name by overworking a useful and willing piece of equipment.

In my opinion, competition with steam should not enter the considerations. There are many applications in the Navy main-propulsion field where Diesel engines are superior to steam, and Diesel engines will be used in any application where the superiority becomes apparent. This superiority is based not alone upon economy with longer cruising radius, it must also be based upon reliability, long life, and low cost of maintenance. The Navy itself has been guilty in demanding that a Diesel engine do more than it is built to do, and the industry has only too often concurred in the demand. It is a mutual responsibility, and I would like to build up a reaction in the Diesel industry to have the engine manufacturers demand definitely the conditions of continuous power under which their products will be required to operate. If this is known and Diesel drive is indicated, enough units can be placed in the plant to furnish the continuous duty required with an adequate reserve for emergencies.

NEED FOR LIGHTWEIGHT HIGH-SPEED DIESELS FOR PROPULSION

The Navy is constantly engaged in a program of research and development. We are striving to develop very lightweight high-speed Diesel engines of proved reliability and considerable power. We have an urgent demand at the present time for such units, varying from 3000 to 5000 hp. When such a unit becomes an accomplished fact, the field for Diesel engines will be broadened considerably, particularly in the application of power through multiple alternating-current drive.

A most interesting development along this line has been undertaken with several of the leading Diesel-engine manufacturers. In one case in particular, after some difficult research problems were solved, an engine is in limited production which far excels our previous experience on a weight-per-horsepower basis. This unique development was begun in 1937, under the sponsorship of Rear Admiral H. G. Bowen, when that officer was Chief of the Bureau of Engineering, and the development has continued over the intervening period. This engine is familiary known as the "Pancake" and is a 16-cylinder, 4-bank radial, two-cycle Diesel engine with the banks stacked vertically. It is capable of delivering a maximum of 1200 hp on the test stand, and its weight-power ratio on that rating is about 4 lb per hp. However, in my opinion, the power rating for continuous duty as a main propulsion unit for this engine is somewhere between 800 and 900 hp. On that basis, the weight-power ratio is between 5 and 6 lb. The engine is now undergoing a life test at the Engineering Experiment Station, Annapolis, for the purpose of determining accurately its acceptable continuous-duty rating. Regardless of its rate, it is a forward step in Diesel-engine development, as it runs $^1/_3$ to $^1/_5$ the weight of current marine Diesels with comparable output, and in the matter of compactness, it occupies from one half to one third the space required by more conventional engines. This line of development is being pursued by other companies in co-operation with the Navy, and we expect to derive great benefits from such experimentation.

GAS TURBINES FOR PROPULSION

In the field of research and experimentation, reference should be made to the development of gas turbines. This development has been in abeyance for some time because of a feeling that there was no thermodynamic cycle which could make it competitive with the internal-combustion engine; but that myth has been exploded by the Houdry process of making high-octane gasoline for the Air Forces. The Navy believes that the gas turbine will be of great importance as a main propulsion drive in the future and is actively engaged in its development with at least four companies. As soon as we can build a suitable plant under the present stringent conditions of critical materials in accordance with design and experimentation already worked out, we shall apply this power to the propulsion of a medium-sized vessel to obtain operating experience so necessary for best results. The gas turbine offers a most challenging incentive to the engineering profession, particularly in the field of metallurgy, and the interest in this matter is widespread.

CONTINUOUS ENGINE-TEST PROGRAM CARRIED ON

It must be recognized that a function of importance to the Navy is the process of testing continuously the different Diesel engines installed in naval craft under controlled conditions and expert supervision. The Bureau of Ships does this in the Engineering Experiment Station at Annapolis. Here scores of engines of all types undergo life tests to determine their endurance, continuous-power rating, and necessary improvements before and while they are in service. The Experiment Station is kept informed at all times concerning new operating conditions that the engines are expected to encounter in service. Special research on bearings, piston rings, and lubricating oil is continuously being conducted to reduce the wear and tear on the engine parts in service and to aid in the quick solution of problems and troubles encountered afloat. The staff of experts and the facilities of the station are at all times accessible to the industry. Close co-operation with this institution cannot fail to be beneficial in the development of the Diesel engine.

Canadian Pacific Railroad

VIEW OF TORONTO WATERFRONT

(For story of A.S.M.E. Meeting with The Engineering Institute of Canada, September 30–October 2, see pages 683–684.)

DIESEL-ENGINE MAINTENANCE *in the* NAVY

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MOST of the Diesel horsepower in naval service today consists of high- and medium-speed lightweight engines. This is a point which must be borne in mind when naval Diesel-engine maintenance is the subject of discussion. In reducing our weight-per-horsepower ratio to gain the obvious advantages such reduction offers, we must perforce accept the disadvantages that go with it, the most important of which is increased maintenance. Therefore all cost and maintenance figures given in this paper refer only to the lighter-weight engines and will very likely vary widely from such costs in general use in the merchant marine where the heavier-duty Diesel engine is the rule.

Until 1932, the Navy had confined the application of Diesel engines to submarine propulsion almost exclusively. The only exception was in small district craft and harbor tugs where regular commercial-type engines were installed. The submarine Diesel engines were of first-world-war vintage—slow-speed, direct-connected, with a weight per horsepower of 80 lb. In addition, all the attendant disadvantages were present, namely, critical speeds, rapid loss of available horsepower due to underwater hull fouling, and an inordinate amount of occupied engine-room space. During this period, some slight reduction was obtained when German engines were copied but the adventure into this field was not highly successful.

RAPID DEVELOPMENT OF THE DIESEL IN NAVAL SERVICE SINCE 1932

The strides made by the Diesel industry since 1932 in this country have been phenomenal. It was certainly a fortunate circumstance that in that year the Navy was granted funds which enabled a dynamic Chief of the Navy's Bureau of Engineering, Vice-Admiral S. M. Robinson, to foster a series of development contracts for lightweight medium-speed high-capacity Diesel engines while, concurrently, several manufacturers embarked into the same field in order to meet the demand and desire for Dieselization of railroad passenger locomotives, and the bus and truck services were being invaded by the smaller lightweight Diesel. With the start made in 1932, our submarine service was the proving ground that soon convinced the Navy that this new type of engine had far greater application than in the submarine alone.

While it is not permissible to quote exact figures, the following table shows the relative growth in Diesel-engine horsepower in seagoing vessels in naval service since 1922:

Year	Horsepower (total)
1922	1
1932	1.3
Jan. 1, 1942	12.5
July 1, 1942	26.7
July 1, 1943	100.6

To emphasize further the enormous size of this growth from a different angle, since August, 1941, the number of Diesel-propelled seagoing vessels has been multiplied by 13. In August, 1941, one third of the Diesel-propelled ships were submarines; today, one tenth of the Diesel-propelled ships are submarines. This gives a very definite picture of where the tremendous expansion has taken place, namely, in surface craft. In presenting the foregoing figures, no mention has been made of the huge number of landing boats, picket boats, retrievers, and other small craft. As a means of comparison, however, it can be stated that these craft can be represented in the table by the relative figure of 12 or roughly one eighth of the seagoing Diesel horsepower in service on July 1, 1943. The engines in these craft are of the automotive type, and are therefore in the high-speed lightweight range as opposed to the medium-speed lightweight engines in seagoing vessels. Hence their maintenance problems are only partially comparable to the larger engines and are further complicated by the distinctly different type of duty performed by the boats.

One point of great importance should be noted: Until the start of this war, the application of the newer type Diesel engine was made in a gradual and orderly manner so that the fine nucleus of trained officers and men in the submarine service was educated carefully in its operation and maintenance. As the pilot models of surface vessels were constructed, this nucleus of trained Diesel engineers in the Navy was sufficiently large to operate and maintain these vessels efficiently. When, however, the need for mass production of Diesel-powered ships arose and shipyards began pouring them down the ways, this relatively small group was soon absorbed, and at least until very recently, ships were staffed by green, inexperienced engineering forces.

Before considering the details of the maintenance problems involved, it is essential that the very distinct type of service encountered today be delineated and certain ground rules laid down to permit intelligent understanding of the maintenance problems discussed later. As already pointed out, our personnel situation in peacetime was nearly ideal. With the huge expansion in personnel that came with the war period, men and officers with only rudimentary engineering knowledge had to be molded, in a matter of months, into operating and maintenance engineers. It is a distinct tribute to these men that they have carried on in a generally efficient and surprisingly capable manner. They have taken their ships to sea in any kind of weather; they have fought submarines, planes, ice floes; they have made repairs when their physical stamina was at its lowest ebb from loss of sleep, seasickness, and the pounding inherent in their lightly constructed craft. This has all been done by inexperienced men who, short months before, were clerks, salesmen, college students, farmer boys, or were otherwise employed at occupations of the average American. In spite of their heroic efforts, however, it must be apparent that the maintenance of engineering plants, because of difference in peacetime and wartime personnel, is one of the Navy's major problems.

LEISURELY PEACETIME SCHEDULES OUT FOR THE DURATION

During peacetime the United States Fleet operated on a schedule that was laid down a year in advance. Engineering runs, engineering upkeep periods, and overhaul periods were carefully scheduled and religiously carried out. New ships,

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before reporting to the Fleet, were given extensive trials and lengthy shakedown periods, after which all defects that showed up were corrected. No engineer officer could complain that time allotted for inspection and upkeep was inadequate. He could plan his upkeep procedure down to the last detail and was provided with plenty of help and tools to carry it out.

In wartime, however, this ideal picture changes. No commander at sea ever has enough ships. We are fighting a war of world-wide proportions and our ships are in every sea and every ocean. The situation changes daily and no responsible commander can do more than lay down a tentative schedule for a very short period in advance. As a result, our ships have to perform their upkeep "on the fly" at all hours and many times in out-of-the-way places where no outside facilities are available. Inspections can only be made at irregular intervals and in most cases in an incomplete manner. The days of extensive trials are over and shakedown periods are normally confined to the trip from the outfitting yard to the operational command. Defects that show up can only be corrected if they are of such a nature as seriously to impair the military characteristics of the ship.

Another serious situation which directly affects the maintenance of naval-engineering plants is the amazing speed with which shipyards are turning out new vessels, especially in the lighter class of ships, the class which is predominantly powered with Diesel engines. This speed is of course only possible by mass-production methods and the employment of thousands of extra employees, most of whom are inexperienced. It is only natural that the running of pipe lines for cooling systems, air starting systems, lubricating-oil and fuel-oil systems in such a speed-up will not be accomplished in a normal peacetime manner.

In addition, such speed-up requires trades of various descriptions to work simultaneously so that interferences are experienced, dirt accumulation, welding splatter, and various other forms of foreign matter find their way into systems which are normally kept meticulously clean. The necessity for acquiring appurtenances such as valves, stuffing boxes, tees, elbows, and the like in tremendous quantities results in many shipbuilders being required to take substitutes which are not of the highest standard. Castings are rushed from the foundry to the machine shops, and to the shipbuilders, in many cases in such a hurry that proper cleaning of foundry sand and core wires is not always accomplished. The net result of such a speed-up, particularly in the early stages of a contract, is that the necessary adjuncts to the engine proper are far from ideal.

When engine operation begins, in spite of the most diligent efforts to keep foreign material from vital parts of the engine, there nearly always is the possibility that foreign matter, sludge, and other detrimental substances will be passed through the engine proper. This results in high initial wear and naturally increased maintenance time and cost. In some cases, the fuel-oil and lubricating-oil systems, as well as water-cooling systems, do not function efficiently as a result of this hasty construction, which again increases the maintenance problem.

In spite of the most careful checking of plans, there must always be left to the discretion of the shipbuilder the location of certain individual items of equipment. Also the enormous number of necessary plans means that inexperienced personnel are making the layouts so that these approved plans are not always ideal examples of good engineering practice. This has resulted, especially in the earlier vessels, in poor accessibility of certain vital components of the engineering installation. There is a maxim aboard ship that "inaccessibility is the greatest enemy of maintenance." The more accessible a piece of machinery is, the better are its chances for proper upkeep and overhaul. Even with well-trained and experienced engineering personnel, the tendency is to allow an inaccessible piece of machinery to be placed very low on the priority list in any maintenance program. While these last two points mentioned are being greatly improved, if not corrected entirely in the later classes of ships, we still have this pressing problem with us.

HIGH SPEEDS COSTLY IN TERMS OF MAINTENANCE

In peacetime, except for emergencies, the Fleet and individual vessels normally operated at approximately the most economical speed. Inasmuch as this economical speed always means that the engines are operating at a comparatively low rating, it is apparent that such peacetime operation was ideal for promoting long life of engines and minimum need for maintenance. In wartime, however, economy of operation is a minor factor. Is is only natural that every commander of a ship in submarine-infested waters desires to run at or near his maximum speed. In addition convoy work requires the escort to make long high-speed sweeps for many hours at a time. The great amount of high-speed running involved in wartime practice increases the maintenance problem manyfold over that found in peacetime.

The Navy figures on peacetime Diesel-engine operation must, of necessity, be based on operation in the submarine service. The average operating time per year per engine in this service was almost identical for all ships and for purposes of this paper will be assigned a weight of 1. Figures for wartime show that our submarines average about 2.5 times this number of engine-hours. Surface craft in the smaller sizes average about 3 times this figure, while in the larger sizes it may be as high as 3.5 times this figure. For use in planning requirements and stocking spare parts we must assume that replacement-part needs will increase in direct proportion to the increase in engine hours. Hence it is evident that maintenance costs in wartime, on a horsepower-per-year basis, will be from 2.5 to 3 times the same costs in peacetime from the engine-hour aspect alone.

SPARE-PARTS REPLACEMENT AS A MEASURE OF MAINTENANCE

An outline has been given of the majority of the factors inherent in ships and in the Navy itself which complicate the wartime maintenance efforts of naval personnel. There are many other factors which directly influence maintenance problems but which may better be laid at the door of the Diesel-engine industry. These will be brought out later in this paper, but first, it is desirable to examine maintenance costs and the method used by the Navy in planning maintenance needs in the matter of spare-parts replacement. Maintenance costs, as mentioned in this paper, must of necessity refer to spare-parts replacement. It is an impossibility even to estimate the maintenance time in terms of dollars and cents, or on a common man-hour basis when engineering personnel has such a wide variety of ability and training.

A study of a typical submarine division during peacetime was carefully made. This division consisted of six vessels with three makes of Diesel main propulsion plants installed. There were two of each type, all of which had been completed within a few months of each other. Their engine-hours were approximately the same for an entire year of operation. The average cost of spare parts for this division per horsepower per year was $1.64. The split between types was not unusual and not far from average. The prices in effect at that time were approximately 15 per cent higher than current prices, mainly due to the small volume in which engines were then being bought. A readjustment of this factor will bring the average cost to $1.39 per horsepower per year.

For the first year of wartime, figures are available for some 21 submarines with the same type of main propulsion. The average per horsepower per year from this study was $4.24. As most of these parts were procured prior to wartime, their average price above that of today is about 10 per cent which brings this figure for direct comparison purposes to $3.82 per horsepower per year.

If the figure of $1.39 per horsepower per year for submarine peacetime operation is given a weight of 1, then the wartime

weight would necessarily be 2.5 because of the increased number of engine-hours. This would indicate that wartime submarine-maintenance costs should be $3.48 per horsepower per year which agrees very closely with the actual wartime-study figure of $3.82. Using this same line of reasoning the surface-craft cost should be $4.17. Unfortunately, it has been a physical impossibility to obtain any data of a consistent nature on surface-craft maintenance cost. We have figures for short periods of time varying from $2 to $8 per horsepower per year. This wide discrepancy is due to battle damage, groundings, and other casualties which are in no way related to actual maintenance of engine parts occurring from normal wear and tear. This brings us to the crux of the whole problem of maintenance of engines in the Navy.

CONDITIONS NOT COMPARABLE WITH SHORE-PLANT DIESELS

A great deal of interest has been expressed in the relationship between maintenance costs of Diesel engines in the Navy and maintenance of similar engines in shore power-plant installations and railroad installations, and the perennial question of Diesel versus steam in naval vessels. A diligent search of all available data leads to the inevitable conclusion that there is no common ground upon which any comparison can be made. These only lead to dangerous and erroneous conclusions. As an example, the very complete Report on Oil Engine Power Costs, prepared yearly by the A.M.S.E., was analyzed by C. F. Foell,[1] who presented curves showing the general average cost of maintenance material throughout to be approximately $1 per horsepower per year. The engines reported on were, in the main, slow-speed heavy-duty engines which ran many more hours per year than the medium-speed lightweight Navy Diesels. Even admitting that we could reconcile these divergent points how can we reconcile the following factors affecting the Navy-installed Diesel?

1 The time two main engines were flooded with salt water when the submarine emerged from a 14-hr submergence.

2 The misalignment caused by enemy depth charges on two of four engines.

3 The occasion on which a hot chase of an enemy ship led close to a sand bar and all coolers became clogged with mud and sand.

4 The time rush battle-damage repairs to the fuel system were made by welding, and several days later welding splatter ruined one set of injectors.

These are but a few of the items that affect wartime maintenance and are actually reflected in the figure of $3.82 per horsepower per year quoted from our study of submarine maintenance.

DIFFERENCES BETWEEN RAILWAY DIESEL AND NAVY OPERATION

Consider then the railroad Diesel installation. Can it not be compared with our peacetime submarine study? Various railroad companies have published figures from time to time which indicate an actual maintenance material cost of from $0.50 per horsepower per year to $2.50 per horsepower per year. An attempt to analyze such figures, however, has not been completely successful inasmuch as it is a virtual impossibility to break down the actual replacement-parts costs from other maintenance items. The great variation in these estimates reviewed are mostly due to type of service and the number of hours of operation per year. They seem to be entirely independent in general of the type or make of Diesel engine installed. Railroads very naturally publish or speak of the over-all cost rather than the simple replacement-parts cost. These factors, plus the very different conditions encountered in railroad service from those encountered in naval service preclude any comparison which is likely to prove of value. The following are some of the outstanding differences in the two types of operation:

1 The naval-vessel installation is always under load when the engine is running, which load is continued for long periods of time as opposed to the idling and intermittent load periods of the railroad installation.

2 The seagoing Diesel exhausts generally into a labyrinth of pipes and mufflers which are not installed to gain the maximum efficiency of the engine but to conform to the military characteristics considered vital for the vessel in which it is installed, while the locomotive Diesel has a short usually straight run of pipe which naturally reduces exhaust back pressure.

3 Lubrication in naval vessels is achieved by pumping from storage tanks which are subject to water condensation, fouling, and scaling, as against a simple system in the locomotive.

4 Salt-water corrosion is always a problem with the naval installation, not only in its salt-water cooling system but in various piping arrangements, whereas the locomotive is entirely free of this problem.

A very earnest attempt was made to procure maintenance costs for naval steam installations to permit some kind of comparison with the Diesel installation. Again, the available data were so incomplete and so involved with other costs that no true picture on a comparative basis could be obtained. In this connection, the maintenance costs of steam plants, especially in naval vessels, can in no way be measured by the cost of replacement parts. The maintenance of such plants is not a parts problem but is a man-hour problem. Studies made several years ago by a shipbuilding company tended to show that maintenance costs of steam vessels versus Diesel-powered vessels averaged from 3 or 4 to 1 in favor of the steam vessel. Investigations into Navy Yard overhauls of naval steam vessels indicate that this ratio holds solely on the replacement-parts cost which will naturally vary widely. The cost of retubing a boiler, for instance, is not primarily one of parts cost but of labor and inactive-period costs.

For the reasons thus stated no attempt is being made to compare maintenance costs of other installations with that of the naval Diesel-engine installation. As stated previously, the author believes that any conclusions drawn from such comparisons would be completely erroneous, would lead to fruitless discussion, and do more harm than good to the engineering profession as a whole. It is not meant, however, to imply that Diesel maintenance costs are sufficiently low or that Diesel maintenance problems have been completely solved. Both the Navy and the Diesel industry have "a row to hoe" in this regard.

PLANNING A DIESEL-MAINTENANCE PROGRAM FOR NAVAL VESSELS

In planning a maintenance program for a Navy which is spread over the seas and oceans of the world, and which is continuously and rapidly being augmented by hastily constructed ships engaged in fighting a war against planes, submarines, and surface craft, the actual wear of engine parts cannot be the only consideration. That, of course, is the basic consideration but to it must be added certain factors taking into account any or all of the following points:

1 Duplicate stocking at possible overhaul bases and the termini of convoy routes.

2 Battle damage of both a minor and major nature.

3 Operation at maximum outputs for long periods of time during stress of emergency.

4 Operation by comparatively inexperienced and, in many cases, changing personnel.

5 Lack of even a reasonable time for upkeep and progressive maintenance.

6 Very long and irregular periods between major overhauls.

7 Loss of shipments at sea by enemy action and, above all, losses due to misrouting, dead storage, and the other myriad shipping problems besetting a nation supplying the world with every item it needs from needle bearings to munitions, from food to completed warships (even some of the latter have been at times misshipped).

8 The very high and rapid expenditure of Diesel parts in landing craft in training, because of the nature of their employment, and in actual operation from their vulnerability to enemy action.

[1] "Analysis of Diesel Operating Costs," by C. F. Foell, *Diesel Power and Diesel Transportation*, vol. 19, 1941, pp. 419–423, 594–596, 607–612, 785–789, 959–960, and 964–967.

9 Overhaul by inexperienced personnel whose natural impulse is to renew wearing parts on suspicion.

10 The lack of qualified salvage men at distant stations who can save thousands of parts from being disposed of as scrap.

With the foregoing points in mind and using our prewar submarine-maintenance costs as a guide, it was necessary for the Navy to arrive at a figure which would, to the greatest extent possible, cover our replacement-parts needs and, simultaneously, permit the engine manufacturers to meet the requirements for new engine production. The figure quoted for wartime submarine maintenance includes many of the factors just enumerated. It does not, however, cover the increases due to items 1, 4, 7, 8, and 9; actually the planning figure used is 50 per cent higher than the wartime maintenance cost which was previously indicated as necessary for maintenance of Diesel-driven surface craft. This figure has been widely criticized as being far too high for the maintenance of Diesel engines in the Navy. To date, experience has proved that this estimate is too low.

Once, however, the needs of world-wide distribution, stocking of spares at advance bases in large quantities, and smoothing out of flow lines for supply of parts are in hand, this planning cost will drop tremendously. When this desirable condition prevails, the problems will be greatly simplified. They will not only be simplified by the fact that distribution will be solved, but by the fact that by that time our training program and hard-won experience will have provided our ships with qualified and experienced engineering, operating, and maintenance personnel. In addition, our advance repair bases will be in sufficient quantity and quality to serve the needs of the huge Diesel-powered component of the Navy.

ENGINE RATINGS NOT BASED ON CONTINUOUS OPERATION

Added to the many problems and faults which have been enumerated so far in this paper, there are certain basic problems which are deserving of particular attention. The outstanding of these is the present method of rating the output of Diesel engines.

During the development period around 1932 the greatest goal of all designers, manufacturers, and ultimate users of engines was to pare to the bone the ratio of weight to horsepower. It was only by striving continuously toward this goal that the American Diesel-engine industry achieved the remarkable power units in service today. It was only natural that every designer and manufacturer placed the highest possible rating on his engine. It was clearly understood among engineers conversant with internal-combustion engines that these ratings were not to be construed as continuous day-in and day-out ratings. In the naval service those who had dealt mostly with Diesel engines, i.e., the submarine service, were well aware of the fact that such engines could not be expected to develop their maximum horsepower output for continuous duty. The Bureau of Engineering and the submarine service soon worked out continuous-duty ratings for engines installed in submarines and operated the ships accordingly.

When the wholesale installation of such engines began in surface craft, however, a very different situation arose. In the minds of the commanding officer who normally is not conversant with detailed engineering problems, a 21-knot ship is a 21-knot ship. He has become accustomed to demanding the utmost from his ship when and if it seemed advisable without any great thought to the time element involved in these demands. The steam engineer many years ago had realized this problem and had built a large reserve of power into his design which he was able to do by the fact that he was not endeavoring to pare weight to the barest possible minimum. Also in steam design, the speed and power of the ship are first determined and the power plant then designed for that ship. In Diesel installations, existing, tried, and proved engines of a certain maximum output must be fitted into the ship in multiple units. The impulse naturally is to install as few units as possible which actually results in the ship's being built around an already existing Diesel engine. The hull and the propeller are designed for the total power the naval designer is advised will be available in this combination of engines. Thus no reserve is left, since that was taken away when the engine was rated.

One of the greatest replacement-part problems has been due to the operation of surface craft at or near the maximum output for extended periods of time. The Bureau of Ships has, within the past year, issued directives in which a "continuous-duty rating" has been assigned for all engines in naval service and the maximum rating has been defined as "emergency-duty rating." This has to a large extent alleviated many difficulties. However, it is very difficult to convince the personnel of our ships that a name plate on an engine stating that it is a 2000-hp engine with the name of a reputable manufacturer engraved beneath it is wrong. The Bureau has experienced many objections to its "rating down" of engines as it is called by many of our forces afloat. The Bureau has been forced to the expedient of changing nameplates in order to overcome many of these objections. In the building program now in effect for district craft and auxiliary craft, the specified rating in ordering these engines is the continuous-duty rating as determined by the Bureau from extensive tests.

DIESEL-ENGINE INDUSTRY MUST SOLVE OVERRATING PROBLEM

The steps as outlined are, however, only an alleviation of what has become a very serious condition. The Diesel industry can cure this by two procedures, (1) by accepting the fact that the present engines are approximately 20 per cent over-rated for continuous duty and lower their sights accordingly; (2) by embarking on a unified problem of redesign which will permit present ratings to be maintained on a continuous-duty basis. This means new materials, new designs, or both, for such vital parts as pistons, liners, piston rings, bearings, gears, and some of the lesser appurtenances. The latter step is almost beyond the powers of accomplishment today when industry is faced with an all-out war, the use of substitute material, the poorer workmanship that must accompany our huge speed-up, and the impossibility of interrupting present production lines.

It is a laudable desire among all manufacturers to get out the maximum amount of new engine production in the minimum amount of time as this shows up to the best advantage on the score sheet. Great pressure is always on the engine manufacturer from the shipyards and various other agencies to produce new equipment on or ahead of schedule. From the operating point of view, any speed-up in new production which does not provide for a sufficient quantity of replacement parts with a good reserve for extraordinary uses is of no value. The consistent interruption of production lines that is taking place today to furnish replacement parts is not the fault of any one individual or group of individuals. That it is a fault, however, no one can deny.

The Bureau of Ships and other Government agencies have a certain definite responsibility in this matter and every effort is being made to assume this responsibility. On the other hand, the manufacturer has just as important a responsibility to make provision for providing suitable parts even at the expense of new production schedules. Furthermore, it is just as definitely his responsibility to keep the operating forces in the Navy advised when, in his opinion, too great amounts of certain items are being provided or where, from his service experience, not enough items are being provided. Happily, in many cases, the latter two points have been well handled.

DIESEL MANUFACTURERS CAN AID BY SUPPLYING SERVICE PERSONNEL

Diesel manufacturers can probably do more today for the war effort of the Navy by intelligent use of their service-department personnel than any other one thing. Experienced service personnel from each manufacturer stationed at key points along the

seaboards can, and in a large number of cases have been able to, run down incipient epidemics of part failures long before the Bureau of Ships has received enough information to recognize such an epidemic. We must face the fact that in this day of substitute materials, relaxed inspection, and other evils which go with tremendous expansion, no manufacturer is immune from a sudden outbreak of repeated failures of some vital part of his engine.

Our fleet must be maintained at its maximum efficiency. It can only be maintained in so far as Diesel engines are concerned by the closest co-operation between the Navy in all its branches and services and the Diesel-engine and allied industries. Many of the difficulties which have been enumerated in this paper, over which the Navy has control, are being vigorously and systematically attacked. A résumé of what the Navy has done and is doing and what, from the Navy's point of view, is expected of the industry to correct our problems jointly seems a fitting close for this paper.

COMPREHENSIVE APPROACH TO SOLUTION OF PROBLEMS

Training. The tremendous problems which faced us to provide trained officers and men to operate our Diesel-driven ships are daily being wiped out. Through the wholehearted co-operation and enthusiasm of the entire Diesel industry, working in conjunction with our Bureau of Personnel and Bureau of Ships, a standard curriculum for instruction of Diesel engineers has been promulgated. This excellent treatise was the result of long hard hours of work by qualified representatives of all of our suppliers in the Diesel-engine and allied manufacturing fields together with experienced naval officers. Through the medium of this paper the Bureau of Ships wishes to express its appreciation of the wholehearted co-operation of the industry in this phase and to bring to the attention of this Society the outstanding effort of one of its member groups. There are now in existence at Richmond, Cleveland, and Cornell University schools for Diesel engineers, which, it is believed, will do more to help solve our maintenance problems than any other one effort. These schools are not for designers nor are they for monkey-wrench mechanics. They are pursuing a basically practical course of instruction with sufficient theory to turn out students qualified in all respects to operate the modern Diesel armada of the United States Navy.

Correcting Machinery Installations. Our installations aboard various vessels are being constantly reviewed and when ships become available, every effort is made to bring their engineering plants up to the highest standard possible, thus reducing maintenance problems due to inaccessibility, poor piping, high back pressure, and the myriad other items affecting the maintenance of engines.

Spare Parts. A world-wide distribution of spare parts has been initiated by setting up depots at various key spots which will be automatically stocked, according to the number of ships in such areas, from the Naval Supply Depot at Mechanicsburg. These depots are being staffed with Navy personnel intimately conversant with the Navy's spare-parts problems. In addition, we have called again upon the Diesel industry and borrowed its parts men and technicians, assigning them as service specialists to these depots. Here on the spot we expect the salvage of valuable material to begin through their experience and guidance. The parts men will bring to these depots their background experience in distribution and stocking; the technicians will be available to each repair base and overhauling activity in their area for advice and supervision in the maintenance of engines in which they are expert.

A comprehensive control of shipments is being worked out which it is believed will solve most of the "lost" shipment problems. Screening of the great number of emergency requisitions now being received for Diesel-engine spare parts will become unnecessary after this control of shipments is perfected and automatic flow is established.

Power Limitations. Comprehensive instructions on the power limitations of Diesel-engined vessels have been issued and in spite of the resistance to "rating down" from the forces afloat, these instructions are daily proving to an increasing number of our engineers that they more than make up for the slight sacrifice in speed by the great increase in reliability and the reduction in man-hours expended for overhaul.

Salvaging Parts. Investigations are being actively and energetically pursued in metal spraying, chromium plating, welding, and any other process that offers possibilities for the salvaging of damaged and used parts. Central salvage depots are being set up on each coast where material, impossible to recondition at advance bases, can be assembled and forwarded to activities and plants which can effectively put this material back on the fighting line.

Tables of Replacement Needs. The basis on which our planning of replacement-parts requirements was made has been explained. Now that we have had over a year of wartime operation to look back upon, with thousands of engines in operation, we have a better idea of what our requirements should be. We are in the midst of preparing "Use Tables" for each engine in service. Our field forces are in consultation with those of each manufacturer in the preparation of these tables. Each depot will have these tables as a basic guide for stocking and will be expected to correct them periodically as the service in the depot's particular area indicates the need.

Engine-Life Tests. At the Engineering Experiment Station, Annapolis, the Navy is conducting life tests on every engine in naval service. All failures, breakdowns, malfunctioning of individual parts, and any other unusual operational difficulties are carefully analyzed and studied by competent and experienced personnel. Tests of any auxiliary equipment or any process that offers promise of aid to our maintenance program are constantly in progress. All of the information gathered is made available to the individual manufacturer on his own equipment and to the entire industry on general equipment and processes.

MANUFACTURERS EXPECTED TO APPLY SERVICE EXPERIENCE

None of the steps outlined can be more than partially successful without the co-operation and active aid of the Diesel industry. The Bureau of Ships is interested primarily in two functions regarding Diesel engines: (1) the placing of suitably powered well-designed engines in naval vessels and, (2) the reliable and efficient performance of these engines after the vessels join the Fleet. In this all-out war nothing can be allowed to interfere with the accomplishment of these two functions. In its over-all view, the Bureau is able to pick up incipient faults in an engine and in many cases quickly find a remedy. When this information is given to other manufacturers, it is not believed too much to expect that they will examine their own product with a view to determining whether or not the problem affects them. Again, when processes to improve reliability or cut down maintenance cost and time are proved and offered to the industry, the least that can be expected is that such processes will be tried as soon as possible.

It is only natural for any firm on a production basis to recoil from unnecessary changes. The Navy will not request or demand any change in Diesel engines unless service experience proves it to be necessary. When such a change is requested, however, the industry can rest assured it is necessary. It must be said that the proposals to use detergent oils, porous chromium-plated cylinder liners, and much of our filter program were not received with wide-open arms by the entire industry. Today we have overcome most of the early objections and these proposals are rapidly becoming universal. These three innovations have done more, in the author's opinion, to help solve our maintenance problems than any other similar proposals in many years.

(*Continued on page 663*)

Cylinder and Ring Life With Porous CHROMIUM-PLATED RINGS

By TRACY C. JARRETT

CHIEF METALLURGIST, AMERICAN HAMMERED PISTON RING DIVISION, KOPPERS COMPANY, BALTIMORE, MD.

CHROMIUM-PLATED surfaces for decorative purposes and to resist wear are not new. The decorative type of chromium plate is usually about 0.00002 to 0.00005 in. in thickness and, in most instances, is applied over other electroplates such as copper or nickel. The chromium-plated surfaces to resist wear have a thickness of from 0.005 to 0.030 in., applied directly to the base material, without additional electroplates to obtain a better bond. The plating of tools to resist wear is usually done at a much higher current density than the decorative type, to obtain a hard plate.

Recently a new chromium plate has been developed, known as porous chromium plate, which, like the hard chromium plate, also is applied to the surface to resist wear. The difference between these two plates is in the outer surface. The new type has a porous surface which is applied after the hard chromium has been electrodeposited. To produce a porous chromium plate, the chromium is electrodeposited with a high current density in the usual manner, as shown in Figs. 1 and 2. By reversing the plating current, a stripping action is created and part of the chromium is removed from the outer surfaces, producing a porous condition, Figs. 3 and 4. This porous condition usually extends about 0.001 to 0.0015 in. in depth, leaving the rest of the plate as it was orginally.

In the porous-chromium-plating of cast-iron piston rings, the plate is deposited directly on the surface of the ring without the use of other electroplates. The rings are plated only on the cylinder-contacting surfaces (OD). After plating, the edges where the OD joins the side faces are rounded with a slight radius. The radius on the OD edges of the cast-iron rings should blend well with the plated surface, Fig. 5.

GENERAL SPECIFICATIONS

Experience has indicated that the chromium plate should be hard and have a bearing surface with a controlled porosity for seating. Periodic examination of many samples and tests of several thousand rings in field service led to the establishment of the following specifications:

1 All surfaces to be plated shall be honed, removing all traces of turning, before chromium-plating.

2 For rings up to a nominal diameter of $6\frac{1}{8}$ in., thickness of chromium plate, including porosity, shall be 0.004 to 0.006 in.

3 Thickness or depth of porosity on the OD surface of the chromium-plated rings shall be 0.001 to 0.0015 in.

4 Profilometer readings expressed in microinches rms and measured on the chromium-plated surface at right angles to the side faces, shall be 45 to 90.

5 Hardness of the chromium plate, as measured on the hard chromium surface expressed in Knoop hardness numbers with a 100-gram load, shall be not less than 775.

6 The porosity shall be created by reverse current.

7 Rings shall be subjected to boiling water for one hour to remove possible traces of hydrogen.

To fulfill these specifications, it is essential that very accurate chemical control be exercised on all plating solutions and plating conditions.

RING SEATING

The porous-chromium-plated ring has decided advantages over the usual hard chromium plate. The porous OD surface permits the ring to carry oil for immediate seating purposes, and at the same time permits it to wear quickly and produce its own mating surface for its particular barrel. At the present time, it should be pointed out that only one porous-chromium-plated ring is used in aircraft engines and two rings for Diesel engines on each piston, and these rings are installed in the top grooves. The porous surface with a thickness of about 0.001 in. tends to bring the cast-iron rings in the lower grooves to a faster seat than if a nonporous chromium plate or plain cast-iron ring were used, with less wear.

When engines operate under sand conditions, cast-iron rings and barrels tend to wear rapidly, the action apparently being for sand particles to loosen particles of iron and, acting together, to cause abrasion. These two abrasive materials, it is believed, travel down the barrel causing all of the rings to wear, with the top ring absorbing the greater portion. Sand or dust particles naturally would not wear the hard chromium-plated surface, and obviously the total amount of wear would thus be reduced.

Examination of a great number of engines in the field has shown that no ring feathering has occurred when a porous chromium ring is used in the top groove. This would tend to indicate that the porous-chromium-plated surface prevents wear from the dust and sand and reduces the amount of abrasive material contacting the remaining cast-iron rings. Not only does the plated ring appear to resist a greater part of the wear, permitting the other rings to have a greater life, but it also reduces the barrel wear considerably.

It is not necessary to lap the cylinder-contacting surface of a porous-chromium-plated ring, as the porous surface gives the plated ring the unusual property of seating promptly in the barrel itself. If the porous surface were not present on the plated ring, then it would be necessary to go through the tedious procedure of lapping the OD surface before installation in the engine.

The fact that the top plated ring reduces ring and cylinder wear also permits the operator to gain extra power from the engine without endangering the ring installation. This factor, combined with the ability to resist wear under severe operating conditions, enables the engine to operate at good efficiency for a longer time and with better performance of rings.

While the data included pertain to aircraft engines, a similar relationship applies to the cylinder and ring life of Diesel engines. The sizes of Diesel ring installations vary from 4 to 22 in. Data showing cylinder wear and ring life of aircraft engines are given in Tables 1, 2, and 3. As a means of comparison, engines of the same type using cast-iron rings have also been included. Cross sections of the rings are shown in Figs. 6 to 9, inclusive.

GENERAL CONCLUSIONS

All other things being equal, engines using porous-chromium-plated rings in the top groove of each piston accumulate a

Presented at the National Meeting of the Oil and Gas Power Divisions, Baltimore, Md., June 14–16, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

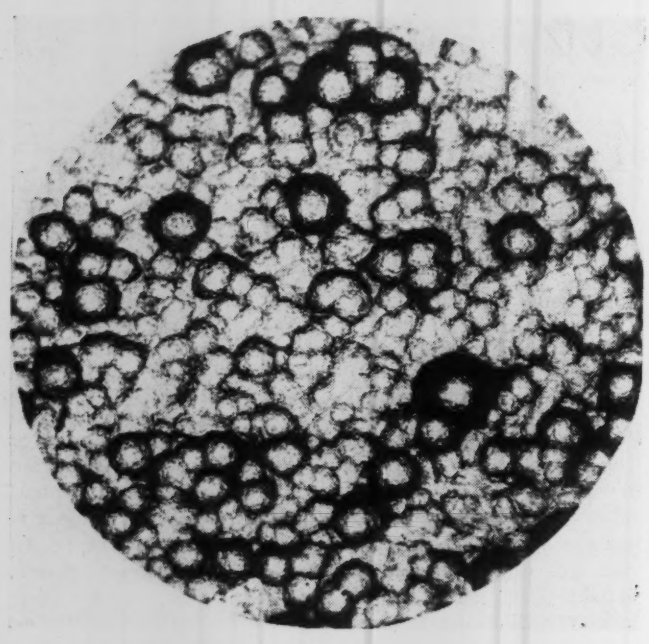

FIG. 1 OUTSIDE SURFACE (OD) OF HARD-CHROMIUM-PLATED CAST-IRON PISTON RING; ×100

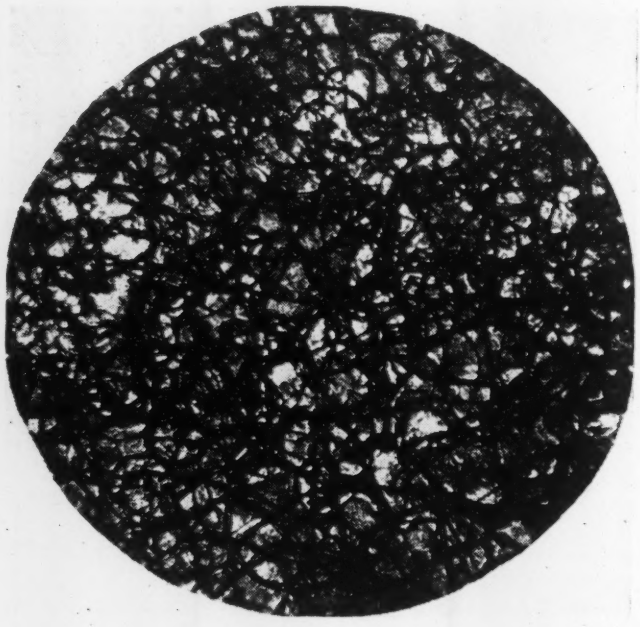

FIG. 3 OD SURFACE OF POROUS-CHROMIUM-PLATED CAST-IRON PISTON RING; ×100

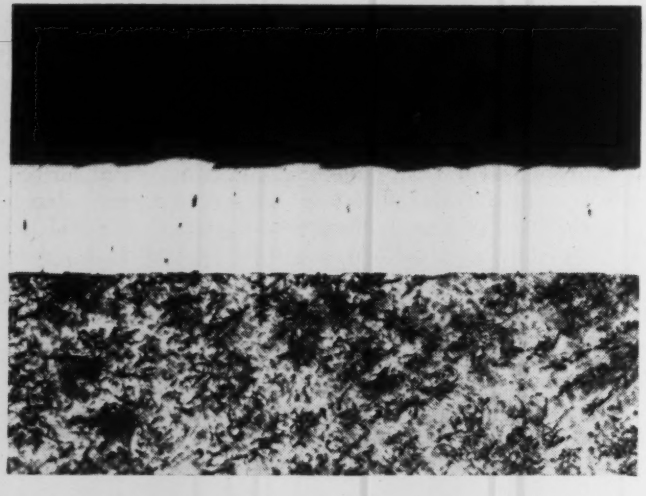

FIG. 2 CROSS SECTION OF HARD-CHROMIUM-PLATED CAST-IRON PISTON RING, NITAL ETCH; ×100

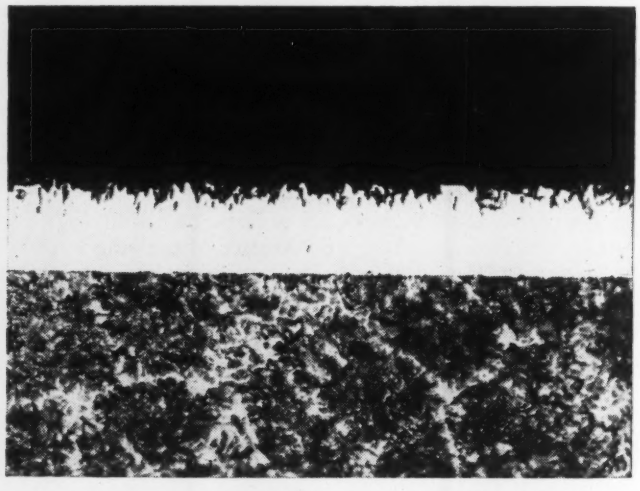

FIG. 4 CROSS SECTION OF POROUS-CHROMIUM-PLATED CAST-IRON PISTON RING, NITAL ETCH; ×100

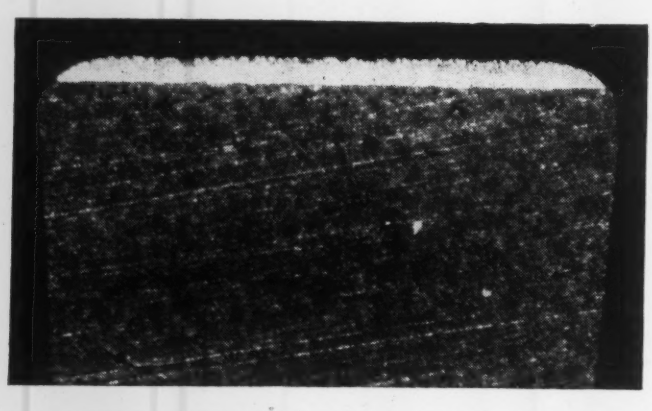

FIG. 5 POROUS-CHROMIUM-PLATED CAST-IRON RING, SHOWING BLENDING OF RADIUS; ×25

greater number of hours between overhauls than engines using all-cast-iron rings. The cylinder of an aircraft engine using one plated ring in the top groove, taken from an average of 10 engines, wears about 0.001 in. per 500 hr, and the same type of cylinder with plain cast-iron rings without chromium-plated rings wears about 0.004 to 0.005 in. per 500 hr. This indicates

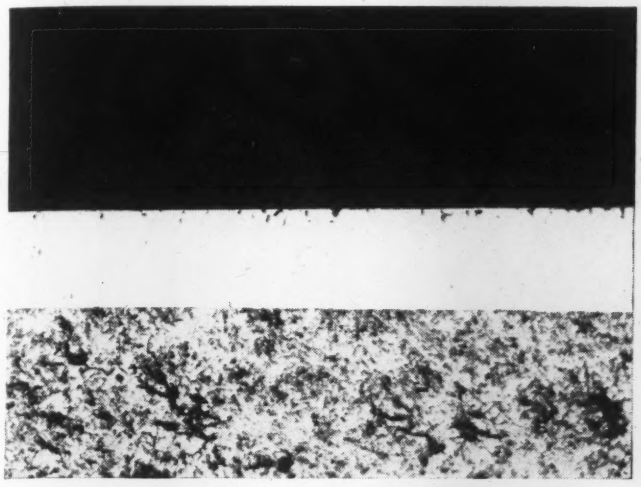

FIG. 6 POROUS-CHROMIUM-PLATED CAST-IRON RING AFTER 36 HR OF ABNORMAL OPERATING CONDITIONS, NITAL ETCH; ×100

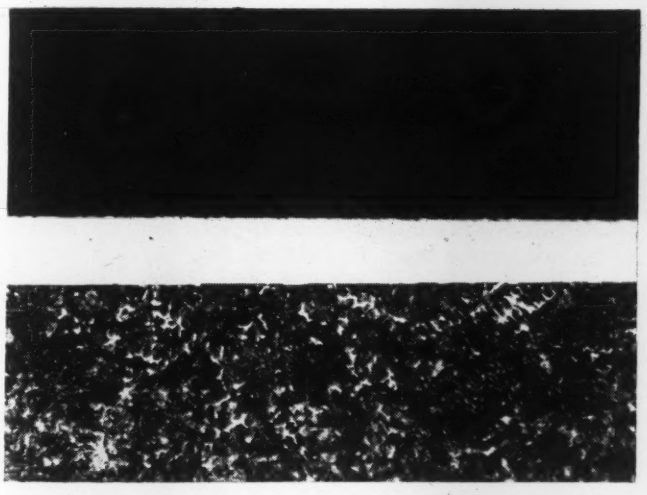

FIG. 7 POROUS-CHROMIUM-PLATED CAST-IRON RING AFTER 505 HR OF ABNORMAL OPERATING CONDITIONS, NITAL ETCH; ×100

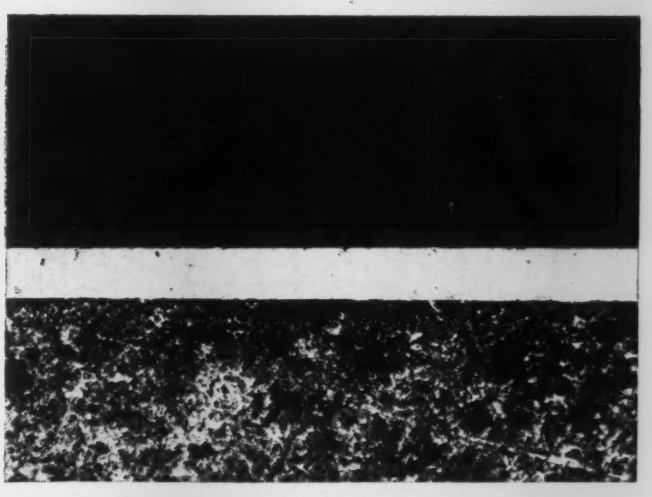

FIG. 8 POROUS-CHROMIUM-PLATED CAST-IRON RING AFTER 601 HR OF ABNORMAL OPERATING CONDITIONS, NITAL ETCH; ×100

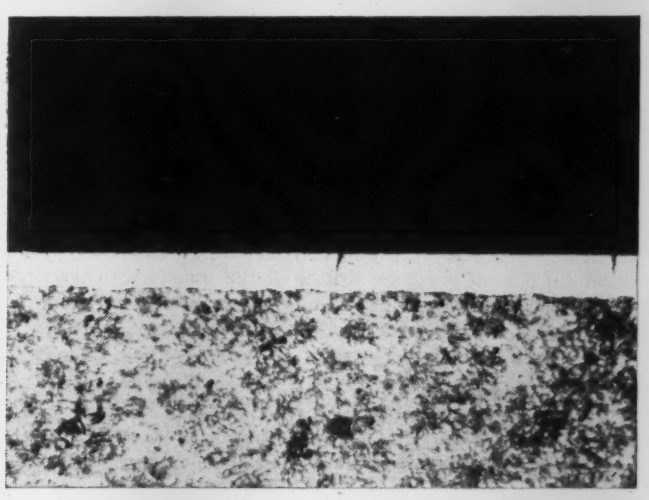

FIG. 9 POROUS-CHROMIUM-PLATED CAST-IRON RING AFTER 779 HR OF ABNORMAL OPERATING CONDITIONS, NITAL ETCH; ×100

TABLE 1 CYLINDER WEAR OF ENGINES RUN WITH PLAIN CAST-IRON RING OPERATING UNDER ABNORMAL DUST[a] CONDITIONS

Engine no.	Approximate horsepower	Number hours operating time	Cylinder wear measured on diameter, in.
A	1200	409	0.0070
B	1200	500	0.0060
C	1200	529	0.0040
D	1200	652	0.0060
E	1200	658	0.0040
F	1200	743	0.0030

[a] The abnormal dust conditions referred to are similar for the comparisons shown in Tables 1, 2, and 3.

TABLE 2 CYLINDER WEAR OF ENGINES RUN WITH POROUS-CHROMIUM-PLATED RINGS OPERATING UNDER ABNORMAL DUST CONDITIONS

Engine no.	Approximate horsepower	Number hours operating time	Cylinder wear measured on diameter, in.
G	1200	124	0.0005
H	1200	415	0.0000
I	1200	499	0.0020
J	1200	601	0.0010
K	1200	651	0.0010
L	1200	785	0.0010

the reduction in wear by using the chromium-plated ring. The chromium-plated ring shows little increase in gap, and it can be seen from Table 3 that the wear of the chromium plate is small when taking into consideration that the original chromium-plate thickness was from 0.004 to 0.006 in. It is seen that by using a porous-chromium-plated ring the time between overhauls will be increased and the cylinder and ring wear will be greatly reduced.

TABLE 3 RING WEAR OF POROUS-CHROMIUM-PLATED RINGS OPERATING UNDER ABNORMAL DUST CONDITIONS

Engine no.	Approximate horsepower	Knoop chromium plate hardness[a]	Number hours operating time	Remaining chromium thickness,[b] in.	Average wear,[b] in.
A	1200	799	36	0.0050	0.0000
B	1200	854	505	0.0035	0.0015
C	1200	800	601	0.0025	0.0025
D	1200	798	682	0.0038	0.0012
E	1200	872	771	0.0038	0.0012
F	1200	875	779	0.0026	0.0024

[a] The hardness of chromium plate was tested on the Tukon tester using 100-g load.
[b] Average 0.005 in. chromium thickness on the radius originally.

Redesigning the MACHINE-GUN MOUNT *by the* INDUSTRY-ORDNANCE TEAM

By MAJOR C. D. ALDERMAN[1]

THE old saying that for every good man looking for a job there is a good job looking for a man, partially illustrates the situation when the United States plunged from defense into war and unfolded its well-laid plan for outproducing the Axis nations so that they might be outfought.

Simply stated, the plan was to convert American industry from peace production to war production, but carrying out the plan was the most gigantic and complex problem that any nation had ever faced.

It is true that, generally speaking, our armed forces knew just about what they wanted. It is also true that forward-looking and patriotic manufacturers were ready and anxious to produce it. But the problem was complicated by factors, the scope of which had never been seen before.

To illustrate the problem, let's consider the Ordnance Department. The list of products that had to be made would almost fill a mail-order catalog, and the quantities that they must be bought in would almost give an adding machine "calculation cramps."

But that is only the beginning of the story because today's war machine is no more like the pre-Pearl Harbor machine than the 1942 automobile is like its 1922 predecessor. In fact the development story of our war machine is like the twenty-year story of the automobile condensed into two years.

Because of limited budgets and limited requirements, our pre-Pearl Harbor ordnance material specifications called for job-shop designs and job-shop manufacturing techniques, in the main. There was neither need nor money for mass-production designs, tools, and production lines.

But when Sherman's version of war broke loose it was not a question of how best to design and manufacture war matériel; it was a question of getting the present designs made soon enough, and there was a serious question about our ability to do it.

From this point on the American War Production Epic divides sharply into two closely parallel developments, neither of which could have proceeded without the other, and each of which reads like a separate fairy tale.

We must dismiss the first—the production and mobilization of machine tools and the establishment of mass-production lines—with the bare statement that only in America could it have been done. The story is too long to be told here.

Our story is about how Army and industry engineers working as a team began to break material and machine bottlenecks and began to make it possible for American production men to beat the Axis production men. Probably the best way to tell it is to go step-by-step through the redesign of the caliber-.50 machine-gun mount.

Early in the war it became increasingly evident that the caliber-.50 antiaircraft machine gun had a job to do and was doing the job. However, the pre-Pearl Harbor model was job-shop design and with a great deal of difficulty, the Ordnance Department was getting only about 3600 per month from six plants because of the machine operations involved and the bronze, aluminum, alloy steel, and special parts required in the mount.

A Philadelphia manufacturing plant undertook the problem of designing a caliber-.50 machine-gun mount that would conserve critical materials and critical machine hours and, more important, that could be made by mass-production methods. With true American industry point of view, they also tackled

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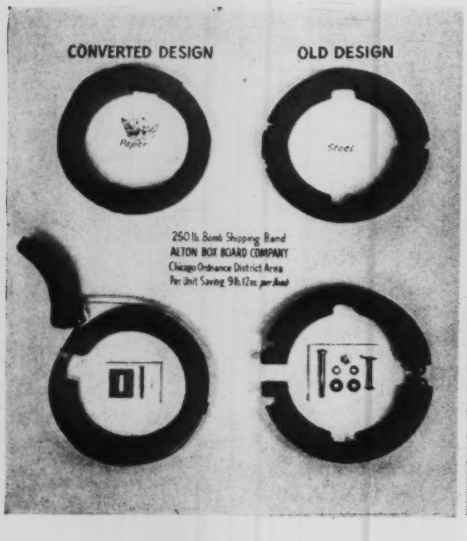
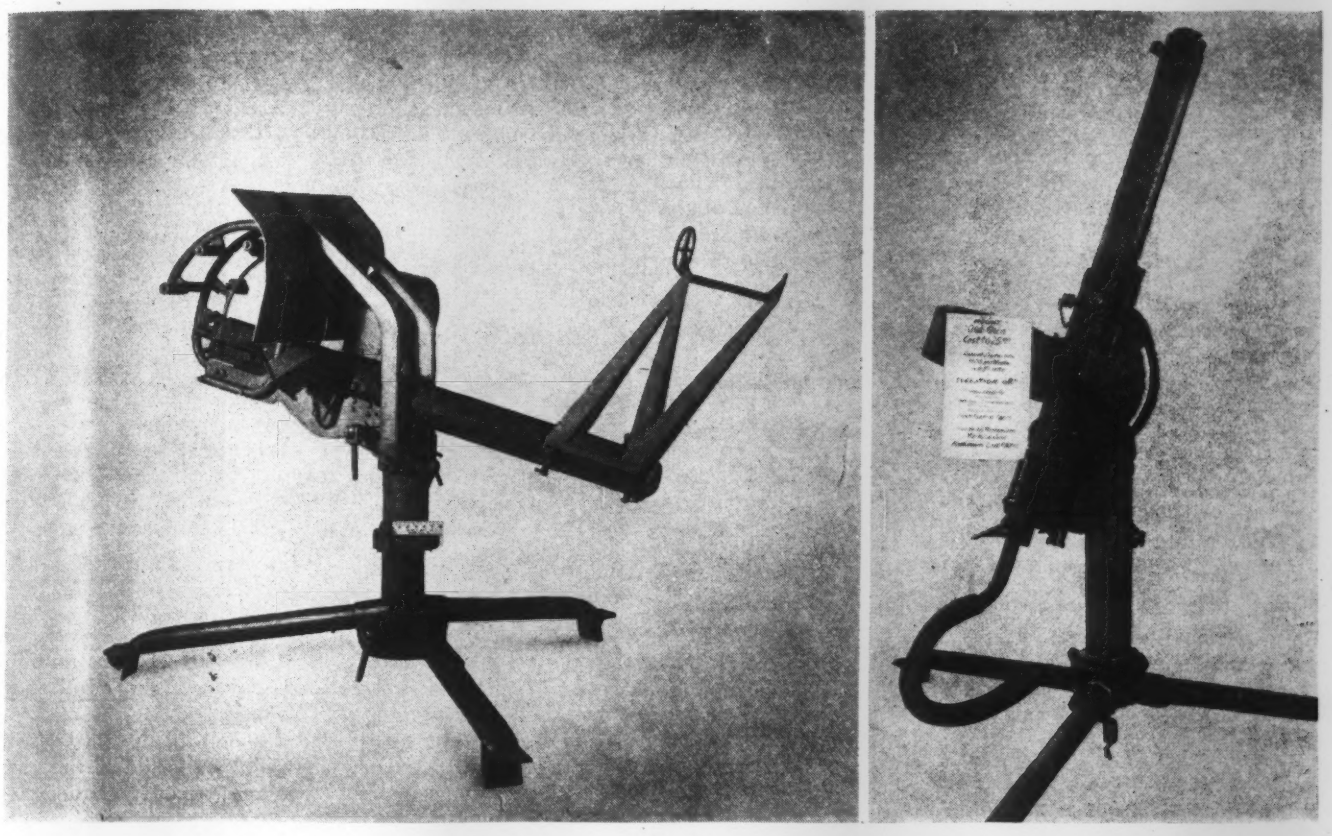


BOMB SHIPPING BANDS
(Converted from steel to paper.)

PARACHUTE-FLARE HANGWIRE CONTAINER
(Presswood is substituted for steel.)

AMMUNITION BOX
(Redesigned to save steel and man-hours.)



NEW MOUNT OLD MOUNT

CALIBER .50 ANTIAIRCRAFT MACHINE GUN

the problem of the handling, transportation, and operation of the weapon.

The result was a gun mount on which the production in one plant almost doubled the total previously made in the six plants, and, more important, a gun which was a better offensive and defensive weapon by any standards.

The new gun mount could fire at any angle from horizontal to vertical and this without the gunner's being a contortionist, because at any angle he could maintain an erect position. It could be raised or lowered or swung from side to side with ease. It was more accurate against fast-moving targets. There was no complicated sight to interfere with field of vision. There was armor-plate protection for the gunner. A man can operate this new gun for hours at a time whereas the old one had him completely worn out after a two-hour wrestle.

Taking into consideration that this is a mobile war, this gun mount was so designed that it breaks down quickly into serviceably light man loads that can be transported by plane, truck, or hand. By the addition of quick-acting clamps, it is possible to remove the mount from its fixed position or replace it in a matter of seconds without the use of tools. By the addition of a pedestal-base adapter, the gun can be used on boats, trucks, land, or buildings.

The new design eliminates all bronze, aluminum, and alloy steels in the mount. Even the added armor plate is nickel-free, low-alloy. Seventy-five per cent of the forgings and castings were eliminated. Standard stock, sheet, plate, and bar are used in fabrication. All parts, such as pipe, nuts, bolts, bearings, and the like are standard and easily obtainable.

It may be packed and shipped in one case instead of three, saving both materials and shipping space. The spare parts necessary were reduced in both quantity and value.

While the weight was reduced only 34 lb, the saving is greater than indicated because armor plate has been added to the new design. The cost, moreover, has gone down 48 per cent, including armor plate and sight and including all tooling costs.

As is typical of the whole Ordnance redesign program, these net results were accompanied by giving attention to every part as it passed across the designer's board. For instance, the cone in the trigger handle originally cost $2 each as a machined forging and there was no adequate supply. The new design is a coined stamping costing 30 cents each and is readily available.

The trigger control mechanism was originally machined from three forgings requiring 20 machine operations, one of which was 4.7 hours. Steel stampings now require no machining, eliminating this bottleneck and reducing the cost one third.

The feed-way mechanism was originally machined from cast aluminum at a cost of $30. Now it is stamped and formed from sheet steel, requires no machining, and costs less than one half of that amount. Incidentally, the redesign of this mechanism made possible the mounting of either the Army or the Navy ammunition chests.

The parallel to this design and production job can be found anywhere down the long list of Ordnance items that are now flowing with clocklike precision from the plants of American Industry. The historian will probably never be able to enumerate them. A hint of the scope of the job that has been done may be found in the records of the Suggestion and Conversion Section in the Ordnance Department in Washington, or in any one of the thirteen Ordnance Districts. This record shows that during the last year, more than 3000 ideas have been received from industry and Ordnance engineers, all having to do with eliminating material and machine bottlenecks.

It was practically impossible to find a sufficient number of engineers to analyze this flow of ideas that have come in for stretching our stock piles and multiplying our production facili-

ties, although at the end of the first year, at least 2300 of these suggestions had been acted upon.

However, the remarkable part of this whole program of conversion and redesign which has resulted in combining American industry for ideas, is that over 50 per cent of all the suggestions considered have been adopted and are now written into the specifications of the Ordnance Department. What this amounts to in lives saved, materials saved, and in dollars and cents can never be figured, but a conservative estimate on the material side based on Army requirements for 1943 shows the following:

Aluminum: Enough to build more than 20,000 fighter planes.
Copper: Enough for four billion rounds of caliber-.50 aircraft ammunition.
Rubber: Enough for seventeen million 600 × 16 tires.
Steel: Enough for 31,000 railroad oil-tank cars.
Nickel: 64,000,000 lb.
Molybdenum: 4,300,000 lb.
Chromium: 17,500,000 lb.
Brass: 5,200,000 lb.

But the message that Army Ordnance, even though filled with pride at these accomplishments, wishes to leave with American industry is in the words of General Campbell:

* * * *

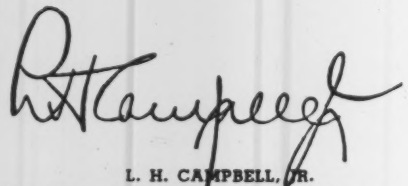
The Industry-Ordnance Team

ANY football coach will tell you that there are no heroics in a tight football game, in spite of the cheers from the crowd and of the writeups after the game. The game is finally won because each man does what he knows how to do, to the best of his ability, and co-ordinates it with what the other men do.

Neither are there any heroics in this serious business of Army Ordnance Matériel Production. We have turned the tide, and we have done so because the engineers in American Industry and the Ordnance Department have worked together as a team, each doing what he knew how to do, all pulling together, fired by the determination to do their best to win.

This ability, this spirit of co-operation, this will to do, will carry us to the solution of the problems ahead, just as they have carried us through those in the past.

The game isn't over yet. There are many more plays to be run before the final whistle blows in Tokyo, Rome, and Berlin. We seek the continued co-operation of Industry in finishing the job that has to be finished over here before it can be finished over there.



L. H. CAMPBELL, JR.
MAJOR GENERAL, CHIEF OF ORDNANCE

TANK FILLER

(Cover and strainer made from steel stampings were substituted for brass and bronze throughout. Protectoseal gasoline tank filler; cover for half track. Unit savings of $8^1/_2$ lb brass.)

RING, PLUG, Snap Gages
Now made from Glass instead of Tool Steel, approx. 50% of all future Gage requirements will be made of GLASS
This Gage Checked 260,000 57MM. Cartridge Cases at Frankford Arsenal. Steel gage wears out at 60,000 to 70,000 operations.

GLASS GAGES

(Glass gages instead of steel gages have many advantages. They cost less, wear longer, and save critical steel. Approximately fifty per cent of all future ring, plug, and snap-gage requirements will be made of glass. Note gage that checked 260,000 57 mm cartridge cases at Frankford Arsenal. Steel gage wears out at 60,000 to 70,000 operations.)

SHELL FORGING *on* BULLDOZERS

By W. TRINKS

PROJECTS DIRECTOR, A.S.M.E. SPECIAL RESEARCH COMMITTEE ON FORGING OF STEEL SHELLS

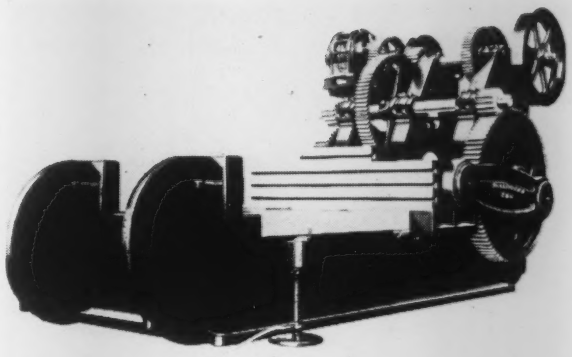


FIG. 2 BULLDOZER FORGING MACHINE

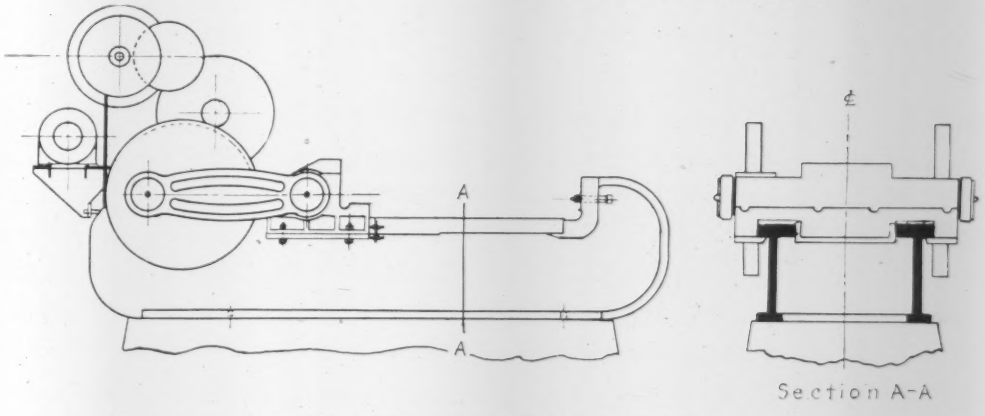


FIG. 1 DETAILS OF HORIZONTAL BULLDOZER

THE forging of high-explosive shells has been widely described in the literature. Hydraulic presses for piercing and drawing, upsetter forging machines, and the pierce-and-cross-roll process have been described so often that the equipment and the processes may be expected to be generally known. Details of two mechanical pierce-and-draw machines, namely, the Baldwin-Omes machine and the Clearing machine, have also been published. On the other hand, the forging of high-explosive shells on the bulldozer has received very little attention in the literature, although the process was practiced here in the United States during the first world war.

A bulldozer is a forging machine, usually horizontal, in which a wide crosshead or traverse is slowly reciprocated by a pitman on each side. Fig. 1 shows a plan and elevation of such a machine, while Fig. 2 shows the machine itself. It will be observed that an electric motor operates the machine through a clutch and a nest of speed-reducing gears. The speed of the reciprocating parts is low. The cranks make 7 to 8 rpm. Dies and punches, strippers, and other forging utensils can be fastened to the solid stationary end block and to the moving crosshead. The bulldozer is used also as a gag press for bending and for straightening. The machine, which is recommended for shell forging, is rated to exert a force of 600,000 pounds in the last inch of the stroke. In the center of the stroke, the force is limited to a much smaller value, unless the machine is equipped with an extra-heavy flywheel. This limitation restricts the machine to uses in which a high resisting force occurs only near the end of the stroke.

Bulldozers have been adapted to the forging of high-explosive shells by several different methods: (1) the "progressive pierce-and-draw" method, (2) the method by which the bulldozer pierces in one stroke, (3) the "French extrusion process."

PROGRESSIVE PIERCE-AND-DRAW METHOD OF SHELL FORGING

The progressive pierce-and-draw method is illustrated by the horizontal section in Fig. 3. The crosshead of the larger machines is usually so wide that two shell-forging lines can be kept going side by side on the same machine, at least for the smaller shells, such as the 75-mm and 90-mm shells. In consequence, Fig. 3 shows only one half the width of the bulldozer.

The heated slug, which may be either round or square in cross section, is inserted into the die bushing (4), where it is slightly compressed by the centering tool (7). The first compressing action is known by various terms such as slugging, upsetting, cabbaging, and, in England, dumping. Its purpose is twofold. The hot steel is pushed into the tapered rear end of the die where it assumes the tapered form of the die. In shell-forging parlance, a "boat tail" is forged on the hot slug. In front, where the centering tool enters, the hot steel is made to fill the die, which causes its center to be raised so that it coincides with the center of the die, and is pierced a very short distance with a truly central hole. The slug is then moved to the next die bushing in which it is pierced part way by punch (8). It is again moved, this time to the third die bushing in which it is finish-pierced by punch (9). The pierced blank then is transferred to the draw mandrel (11) which pushes it through a draw ring (12) and through a pedal-operated stripper against a spring-loaded stop (13) which prints the heat number on the base of the shell. Just beyond the draw ring, the pedal-operated stripper is visible.

The machine element (3) is an ejector bar which is forced toward the die block by means of nuts (1) and (2) and which actuates the ejector pins, thereby forcing the partly forged shell blank out of the die bushings. The element (5) is a stripper bar which is pressed by helical springs against the moving crosshead, but which is stopped by nuts (6) and (10), while the punches (7), (8), and (9) keep moving.

The operators stand on heavy wooden or water-cooled-steel platforms located on top of the die blocks. By means of tongs the operators grasp the emerging blanks and swing them to the next die bushing. Sufficient time is available for this procedure because of the low rotative speed of bulldozers. Fig. 4 shows

Contributed by the Special Research Committee on Forging of Steel Sheils and presented at the Spring Meeting, Davenport, Iowa, April 26–28, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

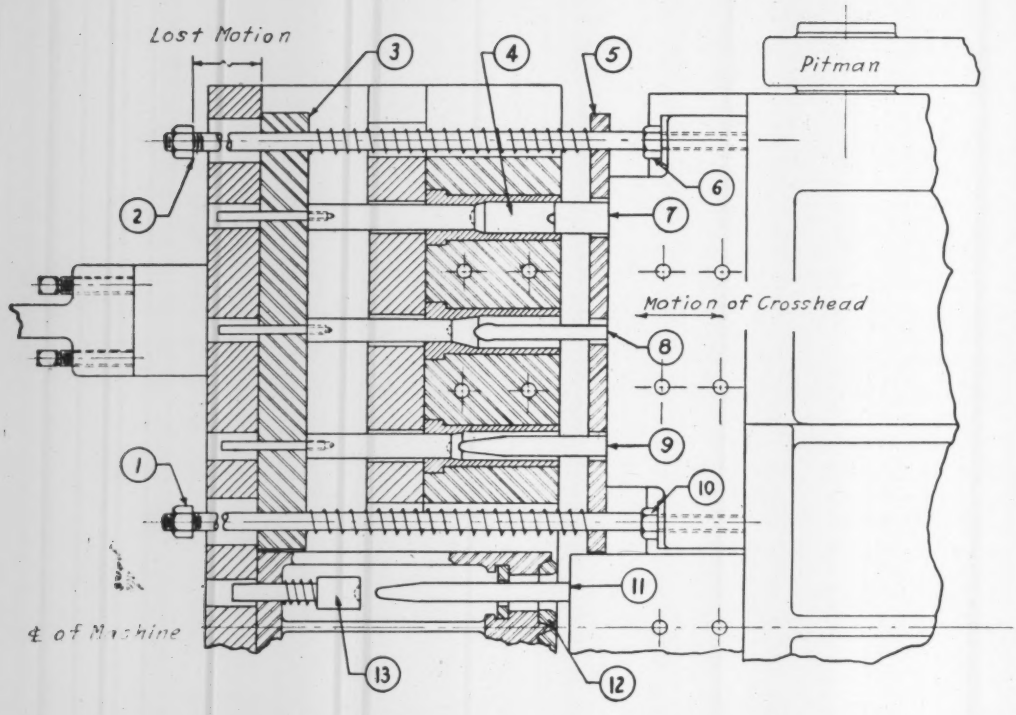


FIG. 3 BULLDOZER FITTED FOR PROGRESSIVE PIERCE-AND-DRAW METHOD

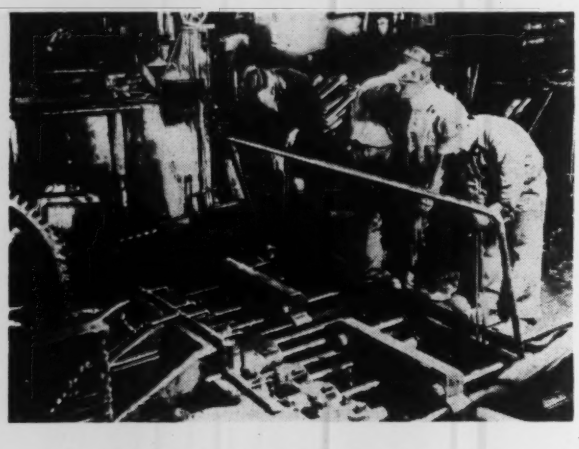


FIG. 4 OPERATORS SWING BLANKS EMERGING FROM DIES TO NEXT BUSHING FROM BEHIND SAFETY RAIL

the operators on the platform around which a safety railing is provided. The men work behind the railing, that is to say, just as if the railing were not in existence. Each operator follows his shell through from crude slug to finish-drawn blank. There are four operators on the machine.

It is quite obvious that the die block becomes much hotter than the crosshead, unless the die block is made hollow and is water-cooled. If it becomes much hotter than the crosshead, there must necessarily exist a difference of heat expansion between these two elements, both laterally and vertically. If the punches were set to be concentric in the die bushings when the machine is cold, then they would be out of center when the machine is hot, and eccentric forgings would be produced. In shell-forging practice, only a very small eccentricity is permitted, for the sake of saving metal and of easy machining. In consequence, the centers of punches and die bushings must not coincide in the cold machine. The following example will illustrate these statements; if the punches are 12 in. apart, center to center, when cold, the die bushings are $11^{15}/_{16}$ in. apart, center to center, when cold. At the beginning of the week hot slugs are used to preheat the die block to the correct temperature.

In addition to the usual precautions of uniform heating, etc., the bulldozer requires an additional precaution. Scale lodges in the bottom of the die bushings and gradually wears them oval in shape. If they are too oval, the shell blanks become crooked in going through the draw ring, forming "banana shells." This action is caused by the thin side stretching more than the thick side.

Practice varies with regard to relative diameters of die bushings. In one shell forge, where 75-mm shells are made from round slugs, the entrance (crosshead) end of the die bushings increases with consecutive operations as follows: Centering bushings, 3.520 in.; first piercer bushing, 3.600 in.; second piercer bushing, 3.678 in. The partly forged blank lies at the bottom of a larger cavity each time and may become slightly eccentric.

Practice also varies with regard to the taper of the die bushings. In the first-named forge plant, the taper (total) is about $^3/_8$ in. per ft.

Fig. 5 illustrates the various stages in the production of a shell blank by the bulldozer progressive-piercing process. The cross section of the slug was square with round corners. The centering depression in the first pass is deeper than necessary or desirable. Slugging is imperfect, much of the original, round-cornered square section remaining visible. Slugging in any mechanical forging machine must necessarily be incomplete, because complete filling of all voids would break or stall the machine. This series of slugs was provided with inserts of mild steel, in order to show the flow of the metal.

Fig. 6 shows the male tools developed in one forge for making 75-mm shell blanks. It is claimed that the bulbous shape of the first piercer removes scale from the cavity. This piercing tool penetrates as deeply as the final shape of the cavity permits. The tools are internally cooled by water, which enters through a small pipe from the rear, returns outside of the pipe, and is discharged through a small lateral hole.

If the bulldozer made a shell on each half of the machine for each forward stroke, 14 shells would be produced per min, or 840 shells per hr. Actually, the best that has been done is to

produce 2 shells every third stroke, or 280 per hr. As a rule, two shells are made every fourth stroke, or 210 per hr.

The bulldozer is well adapted to progressive piercing, because, in the first three strokes, the resistance to forging occurs near the end of the stroke of the crosshead. The draw takes a longer portion of the stroke, but the force is only a fraction of

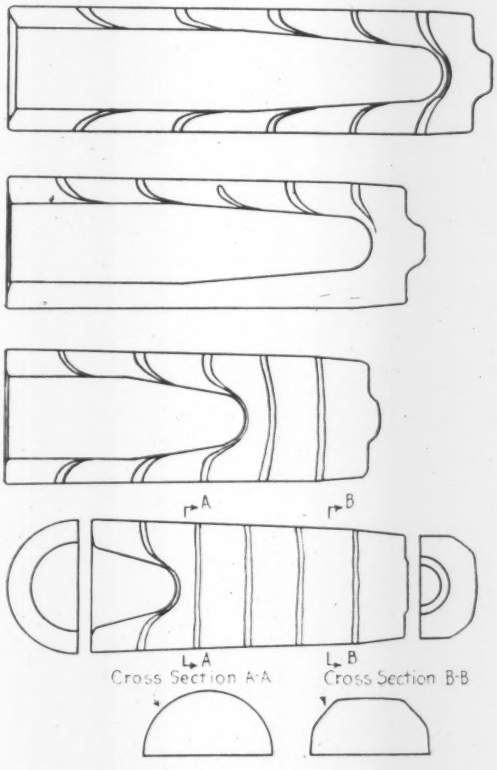


FIG. 5 VARIOUS STAGES IN PROGRESSIVE-PIERCING PROCESS

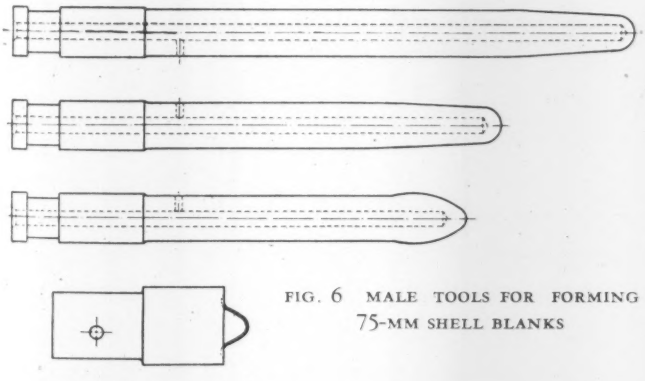


FIG. 6 MALE TOOLS FOR FORMING 75-MM SHELL BLANKS

the force which the bulldozer can exert. A rough-and-ready rule for shell forging is that, for piercing, 40,000 to 50,000 lb are needed for each square inch of cross-sectional punch area; and that, for the draw, 22,000 lb are needed for each square inch reduction of cross-sectional area of shell blank. From these figures, the maximum size of shell which can be produced on a given bulldozer can be computed.

COMBINATION OF PIERCING AND CROSS-ROLLING

The bulldozer is being used also for piercing only, leaving the elongation of the pierced blanks to be done by another process, for instance, by cross-rolling over a mandrel. The combination process produces a thick-walled short pierced blank on the bulldozer. The piercing stroke is short, and the force much less than 50,000 psi of area of cross section of punch. In an example of this sort, four punches are provided in the moving crosshead. They are used successively on successive blanks which means that each punch and die bushing is used once for every fourth blank. Tool life is increased by this method of forging. In one case which was observed, fairly large shells were made, and a heavy eccentric load was exerted on the moving crosshead when the outer punches were used. The machine was stiffened against rapid wear by fastening to the crosshead long rods which slide in the fixed end block of the machine.

"FRENCH EXTRUSION METHOD" OF SHELL FORGING

The bulldozer has been adapted also to a wholly different method of shell forging which is known as the "French extrusion method," and which is claimed to have been invented toward the end of the first world war.

In this method, the word "extrusion" is used in its true sense (pushing out through a narrow opening) and not in the sense which it usually has in the pierce-and-draw process. In that process, it means backward flow of the hot metal along the wall of the die bushing opposite to the direction of motion of the punch. In the French extrusion process, there can be no such backflow along the die wall because the punch is not surrounded by a die.

The principle of the process is illustrated in Fig. 7. A slug is placed in a container *B* into the end of which extends a punch *A*. If abutment *C* is forced into container *B*, the slug is extruded through the gorge *D*. The slug metal flows around the punch and determines its own outside diameter, which means that the relation between punch and die in container *B* must be carefully determined and maintained. It is claimed that there is no flow under great pressure between slug and container except at (and very near) the gorge. In consequence, die friction is reduced to a minimum.

In a practical embodiment, the abutment *C* is stationary, while punch *A* and container *B* move together. The process is carried out in a bulldozer. A plan view of these parts which are important in this study is shown in Fig. 8. The parts at the left are moved right and left by the bulldozer through a slider crank mechanism and are in motion constantly, except in dead-center position. The parts at the extreme right are stationary. The parts shown in the center of the upper two thirds of Fig. 8 move intermittently. The operation is as follows:

A slug is placed (from above) in space (5), while the moving parts are near the dead-center position. The punch moving to the right pushes the slug into container (6). When moving face (1) contacts face (3), the container is pushed to the right. To prevent premature movement of the container, a latch (11) is provided which is released by cam (8). Container (6) and punch (2), moving as a unit, are pushed toward abutment (7), and the slug is extruded (pierced). Upon the return stroke, the pierced blank remains on and is carried back by the punch until it is stripped from it by stripper (4). The container (6) is returned to its original position by the pullback rod (9) which has a head fitting into a recess under (10). The head is hidden from view. In the original scheme, the pierced blank went into the draw ring in the second stroke. In practice, it was found advisable to pierce just a little more deeply in a second operation, by which means the bottom thickness is accurately set, and the base of the blank is cooled sufficiently to prevent the draw mandrel from being pushed through the hot blank. The mechanism of the second piercer is identical with that of the first piercer. Following the second operation, the pierced blank is transferred to position (13), from where it is pushed by mandrel (12) through draw ring (14). Two spring-connected bell cranks act as the stripper on the return stroke of the draw mandrel.

The bulldozer makes 8 rpm, or 480 rph. If the attendants were dexterous enough to remove a blank near the dead-center pause and to deposit a slug in the same place, the capacity of the machine would be 480 shells per hr. Actually, only one half of that number, or 240, are produced per hr, if the heating capacity permits. At one dead center, a blank is moved over

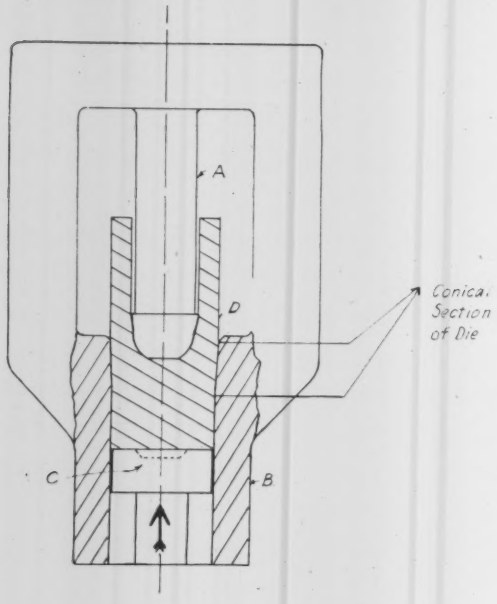


FIG. 7 PRINCIPLE OF FRENCH EXTRUSION PROCESS

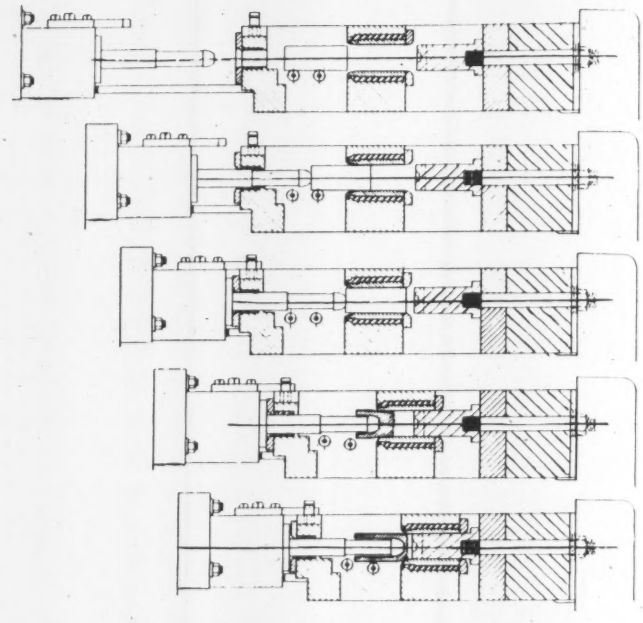


FIG. 9 STAGES IN THE APPLICATION OF FRENCH EXTRUSION METHOD

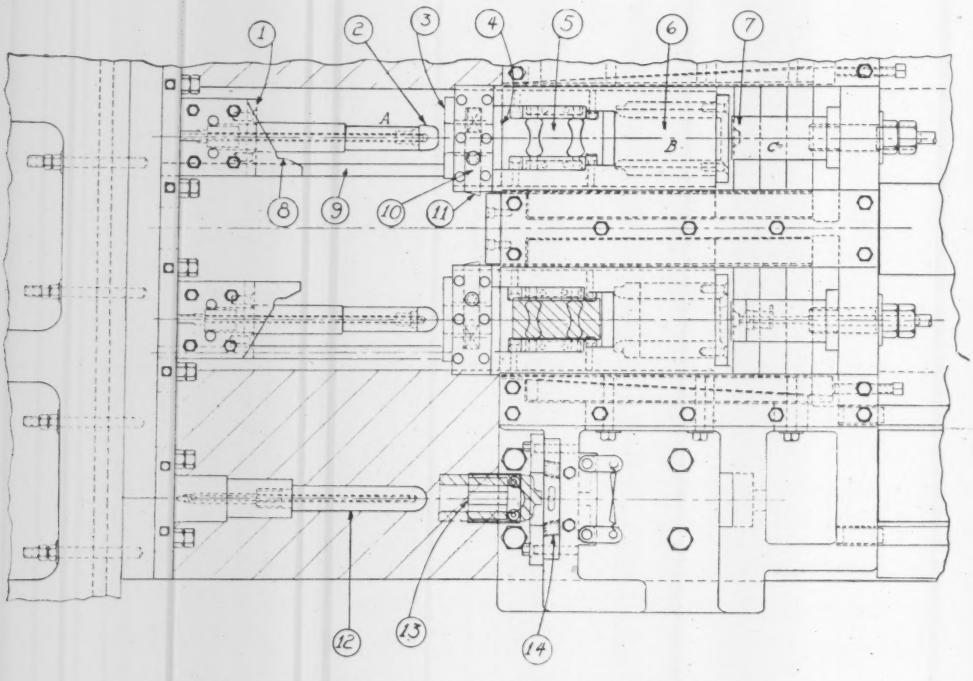


FIG. 8 BULLDOZER FITTED FOR FRENCH EXTRUSION PROCESS

to the next operation and, one revolution later, a new blank (respectively, slug) is put into the same position.

A step-by-step illustration of the process is shown in Fig. 9. Reference numerals were omitted, because the various parts will readily be recognized by comparison with Fig. 8.

DATA AVAILABLE FOR ADAPTING BULLDOZERS TO SHELL FORGING

The question may well arise why this simple process which can be rigged up on any bulldozer has been and is being used so little. For one reason, builders of bulldozers have not as yet undertaken the task of adapting existing bulldozers to the carrying out of this process. Another reason is that few experimental data concerning it have been published. The Special Research Committee on Forging of Steel Shells has such data, contained in a report to the U. S. Army Ordnance Department.

Die friction is not eliminated by this process. While there is no outer die around the greater part of the length of the punch, there is die friction between the slug and the surrounding cylinder. When that cylinder is worn too much, the steel flashes back and produces a cylindrical veil. This action shuts down the machine until new parts can be inserted.

The French extrusion method requires a fairly constant force application over a considerable length of stroke and thus requires force exertion before the bulldozer crosshead has come to a position approaching the end of its stroke.

Shell forging by bulldozers is not as popular as shell forging by other forging machines, such as the upsetter. The policy of the builders of bulldozers to refrain from any publicity may be one of the reasons for this great difference in popularity. However, this does not detract from the fact that good shells can be and are being made in large quantities on bulldozers in several widely scattered sections of the United States.

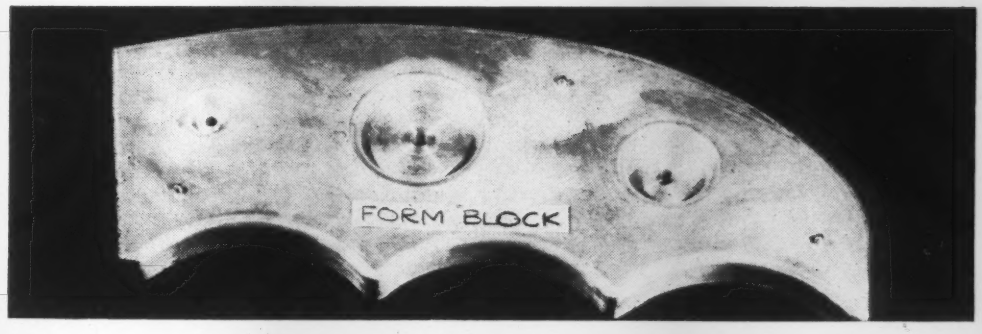


FIG. 1 STANDARD FORMABILITY DIE

A Simple HYDROPRESS FORMABILITY TEST *for* SHEET METALS

By G. C. BARBER

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THE test described in this paper is intended to provide aircraft designers with information concerning the extent to which metal sheets may be bent, stretched, or compressed under the rubber pad of the hydropress.

Information about the workability of sheet metal has existed in one form or another for a long time. Tinners, for instance, know that crimped joints are permissible in certain materials within a certain range of gages, and they know that straight-break flanges may not be bent too sharply if cracks in the material are to be avoided. They have learned that flanges which follow an arc of curvature involve stretching or compressing the material and that it is necessary to make certain concessions in design if wrinkled or torn flanges are to be avoided. The accumulation of knowledge which tinners possess about the materials and the techniques of their trade is what engineers like to call "folklore." It is knowledge, but it is unsystematic, and because of this, it is incomplete in engineering eyes.

The formability test is an engineering expedient for gathering systematic data on the extent to which particular sheet metals will tolerate specific types of deformation. Its value to the aircraft engineer lies in the fact that the information which it is able to provide will enable him to design sheet-metal parts without incurring weight penalties, as a result of needless caution, and will permit him to realize the full potentialties of his material in the design of sheet-metal structures.

CONDITIONS OF TESTING

The test was run on the Guerin process hydropress at a unit pressure of about 1200 psi. The form block is of dural and is so designed that the test specimen is subjected in one operation of the press to all of the general types of forming likely to be encountered.

Fig. 1 shows a standard formability die. On one side of the block there are three stretch flanges and the flat pattern is so designed as to give elongations of approximately 9, 14, and 23 per cent. Along the other side of the block there is a $^5/_8$-in. shrink flange with a radius of curvature varying from 25 in. down to $2^1/_2$ in. At one end the block incorporates a straight-break springback flange with a $^3/_{16}$-in. bend radius. Along the top of the block are placed three atmospheric bubbles, from which are obtained data on elongations where no edges occur. The relative depths to which these bubbles can be formed indicates the "definition" obtainable.

In the forming of the stretch flanges, the edge condition of the blank materially affects the elongations. The edges may be produced by hand shearing and they may be subsequently polished. They may be cut using plow steel and Kirksite "zero-clearance" type dies. The edge may also be blanked using a router block on the master router. In general, sheared edges will not elongate nearly as much as polished or routed edges. This is usually explained by the fact that all methods of shearing produce small cracks or scratches on the edge, which act as stress concentrators, thereby reducing the amount of elongation obtainable before rupture.

Fig. 2 shows an enlargement of some edges sheared with a zero-clearance die. When the edges are polished, these irregularities are removed. When a router is used, any edge irregularities run parallel to the edge of the metal and thereby do not concentrate the stresses.

In Fig. 3 is shown an enlargement of a routed edge. The direction of the irregularities should be noted. High edge elongations are obtainable using polished or routed edges. The effect of edge condition upon elongation is shown in Fig. 4. The edges which were routed or polished did not fail when elongated but the sheared edge split.

The shrink of most sheet metals over convex flanges is affected by the variation in the gage of the material.

In Fig. 5, for example, it can readily be seen that the heavy gage formed with fewer wrinkles than the lighter gage.

Fig. 6 indicates the trends of elongation, shrink, springback, and definition as affected by changes in gage. As the thickness increases, both the shrink and the elongation obtainable

Contributed by the Aviation Division and presented at the Semi-Annual Meeting, Los Angeles, Calif., June 14–17, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

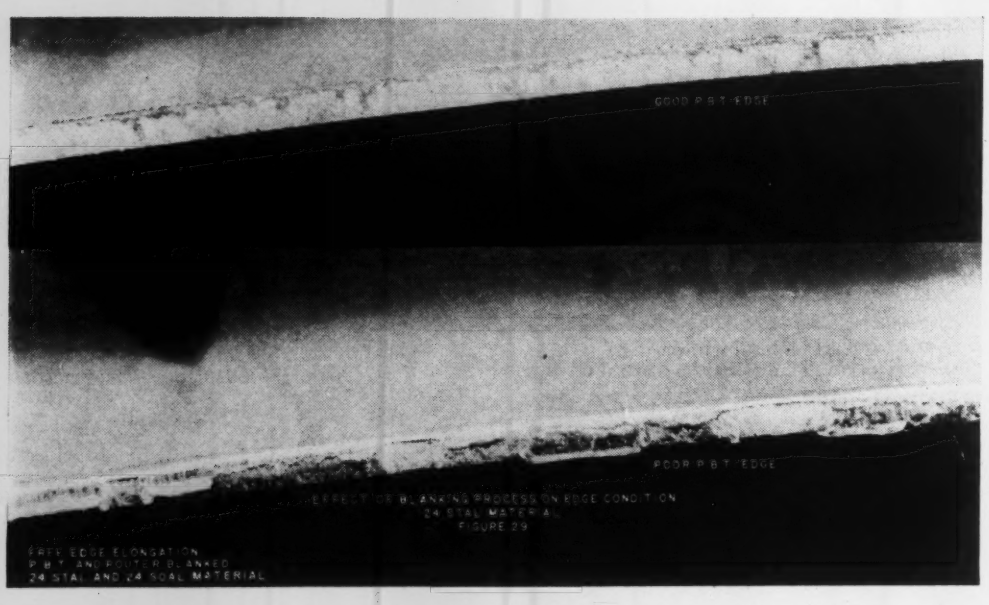

FIG. 2 ENLARGEMENT OF EDGES SHEARED WITH "ZERO-CLEARANCE" DIE

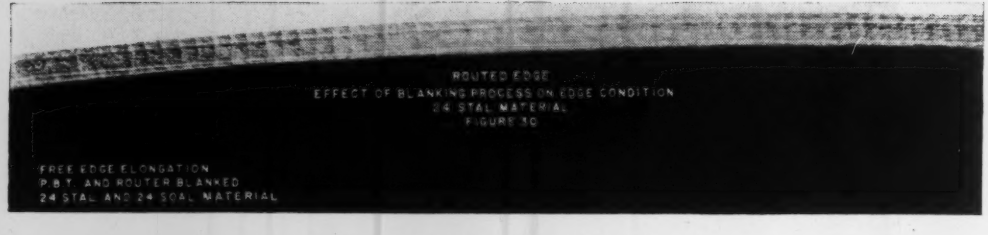

FIG. 3 ENLARGEMENT OF A ROUTED EDGE

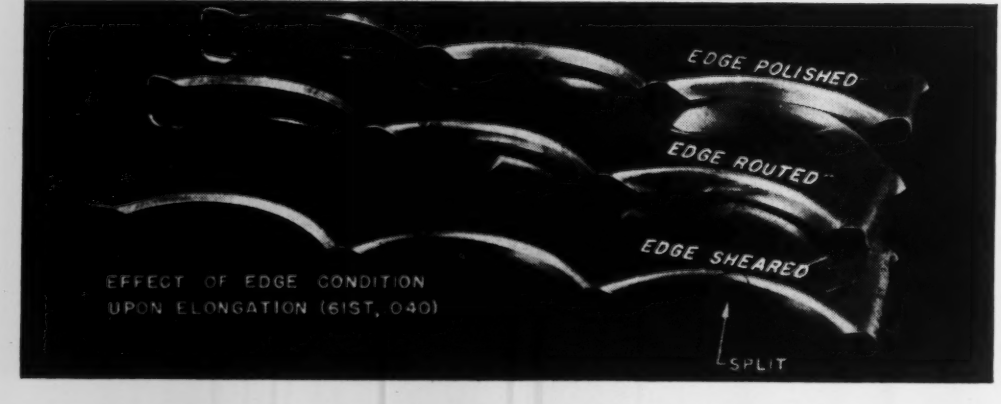

FIG. 4 EDGES ROUTED OR POLISHED DID NOT FAIL WHEN ELONGATED; SHEARED EDGE SPLIT

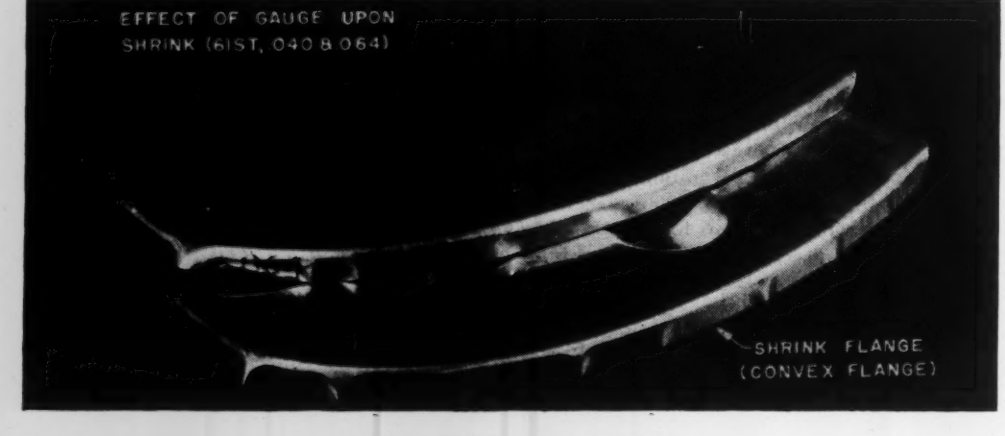

FIG. 5 EFFECT OF GAGE ON SHRINK

increase. For thin gages, the definition obtainable is high, but as the gage increases, the metal becomes more difficult to form into beads and other depressions. For a given bend radius, the springback of thin gages will be a great deal higher than the springback of thick gages.

RELATIVE FORMABILITY OF SUBSTITUTE METALS

Following the recent request by the Army and Navy that manufacturers attempt to substitute 61S alloy for 24S, this test was used to evaluate the relative formability of these two materials in their various conditions. Fig. 7 gives a comparison between 24SOAL and 24STAL, and 61SW and 61ST. Material 61SW was found to have the best elongation and 61ST the least. The relative elongations found from the test agree with the aluminum company's data on the elongations of these materials. By an examination and comparison of the wrinkling of the test samples, 24SOAL was found to have the best shrink and 24STAL the worst. Test samples of 61SW and 61ST fell in between and showed about the same shrink. The relative springback and definition of the four materials ranged in the same order as their yield strengths, with 24SOAL giving the least springback and the greatest definition, 61SW and 61ST falling next, and 24STAL giving the greatest springback and the least definition.

From this evaluation it was finally decided that only in certain special cases could 61SW be substituted for 24SOAL. In general, 61SW could be substituted for 24STAL when forming was necessary and 61ST for 24STAL when no forming was required. In all cases the substitution of these materials must take into consideration the strength required of the part involved, since the 61S alloy has a lower strength than the 24S alloy.

When 24SOAL material is heat-treated and quenched, it must be aged at room temperature for approximately 24 hours before its full strength is reached. To reduce warpage

in heat-treatment, advantage is often taken of the fact that the "green" 24SWAL material, as it is called immediately following quench, can be formed nearly as easily as 24SOAL. In order to determine how quickly this green material must be formed following heat-treatment, the formability test was run on 24SWAL material, varying the elapsed time from the quench.

Along with the 24SWAL samples were run control samples of 24SOAL and 24STAL. All of the 24SWAL samples were iceboxed, and several samples were run in the chilled condition before they had come up to room temperature. It was found from this test that samples run up to 30 min after quenching will form as well as samples run immediately after quenching. However, the poor formability of chilled parts which had not been allowed to come to room temperature indicated that care must be taken to allow iceboxed material to rise to room temperature before forming.

FIG. 8 0.040 GAGE 24SW FORMABILITY TEST SAMPLES

Fig. 8 shows a series of these test samples. Sample No. 1 at the top is a 24SOAL control sample. Sample No. 8 at the bottom is a 24STAL control sample. The two samples directly above the bottom sample were formed in the chilled condition and wrinkled to a greater extent than the four samples above them, which all formed nearly as well as the 24SOAL control sample.

An interesting use of the formability test arose when it was desired to anneal spoiled 24STAL stretcher-press material and to use the annealed material for drop-hammer parts. To determine whether its formability was satisfactory, the annealed material was tested, compared with 24SOAL, and found to be acceptable for the proposed use.

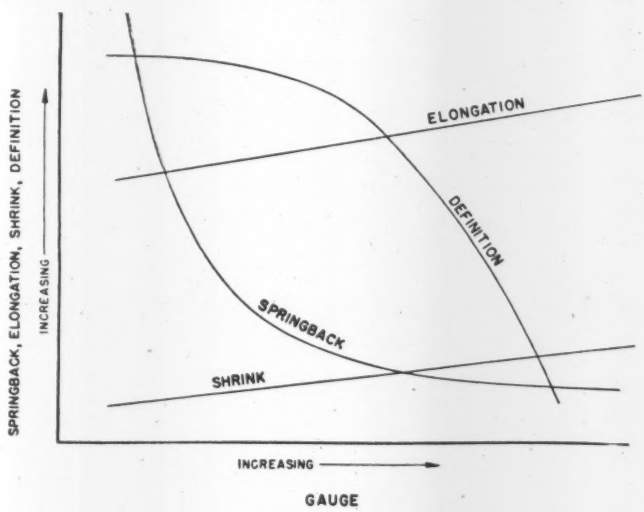

FIG. 6 EFFECT OF GAGE ON FORMING

ELONGATION (DECREASING)	SHRINK (DECREASING)	SPRINGBACK (INCREASING)	DEFINITION (DECREASING)
61SW	24SOAL	24SOAL	24SOAL
24SOAL	61SW, 61ST †	61SW	61SW
24STAL		61ST	61ST
61ST	24STAL	24STAL	24STAL

† NO OBSERVABLE DIFFERENCE

FIG. 7 RELATIVE FORMABILITY OF ALUMINUM ALLOYS

FORMABILITY TESTS USED IN EXAMINING SHEET STEELS

In addition to its use in comparing aluminum alloys, the formability test has also been used in the examination of sheet steels. Following the interest aroused by North American Aviation through its use of S.A.E. 4610 steel in a trainer design, the formability of this steel was evaluated to determine what fabrication difficulties might be encountered, Fig. 9. For parts of equivalent weight the steel was found to fall between 24SOAL and 24STAL in both shrink and springback. The sheared-edge elongation was found to be about the same as for 24STAL. However, due to its higher strength, the definition obtainable was lower than that for 24STAL. In general the 4610 grade B (100,000-psi yield strength) was found to parallel 24STAL in formability.

A substitution recently proposed by the Army was that of low-carbon sheet steel for 18–8 stainless steel. The steel was to be protected from corrosion by suitable surface coatings. In an attempt to obtain a satisfactory substitute, the formability of various low-carbon steels was compared with that of annealed 18–8 stainless steel.

The steels tested were hot-rolled and cold-rolled S.A.E. 1020 steel, hot-rolled S.A.E. 1010 steel which had been "aluminized" by dipping in molten aluminum, and annealed 18–8 stainless steel. The formability of hot-rolled low-carbon steels is in general as good as that of annealed 18–8 stainless steel. However, cold-rolled low-carbon steels are harder to form. Some of the aluminized steel had been subsequently cold-rolled, giving it a harder aluminum surface. An examination of the aluminized steel test samples revealed surface cracks in the aluminum coating.

Since the primary purpose of the aluminum coating was to

protect the easily corroded low-carbon steel, such surface cracks could not be tolerated.

FORMABILITY PREDICTED BY STRESS-STRAIN DIAGRAMS

In addition to the test outlined, use can be made of the stress-strain diagram of a new material to predict its formability. A good example of this application is the case of the prediction of relative springback. Fig. 10 shows two stress-strain curves, one for 24SOAL and one for 24STAL.

Let us examine the bending of two sheets of metal of the same gage but one of 24SOAL and one of 24STAL. When a sheet of 24SOAL is bent, its outer fibers are strained to an amount *C*, and a stress is induced in them equal to *B*. However, when the forming pressure is removed, the stress and strain are unloaded along the line *BD*, which parallels the elastic slope to the point of permanent shape. The resulting permanent strain is equal to *OD*. The difference between the maximum strain under forming and the permanent strain is called the springback.

ELONGATION SHEARED EDGES (DECREASING)	SHRINK (DECREASING)	SPRINGBACK (INCREASING)	DEFINITION (DECREASING)
24SOAL	24SOAL	24SOAL	24SOAL
4610 †† 24STAL	4610	4610	24STAL
	24STAL	24STAL	4610

† GRADE B
†† ABOUT EQUAL

FIG. 9 RELATIVE FORMABILITY OF 4610 STEEL AND 24S ALUMINUM ALLOY

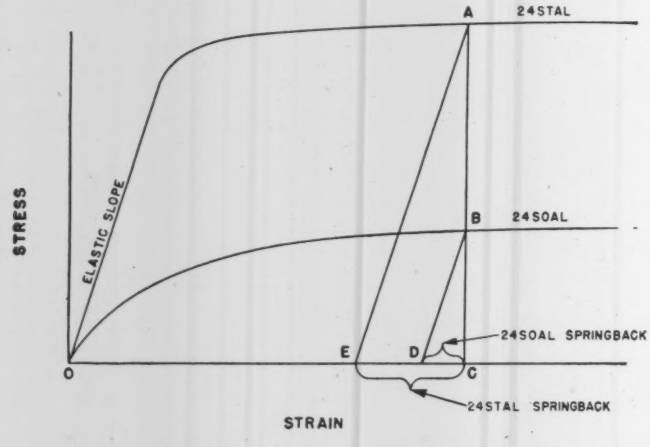

FIG. 10 SPRINGBACK OF 24SOAL AND 24STAL

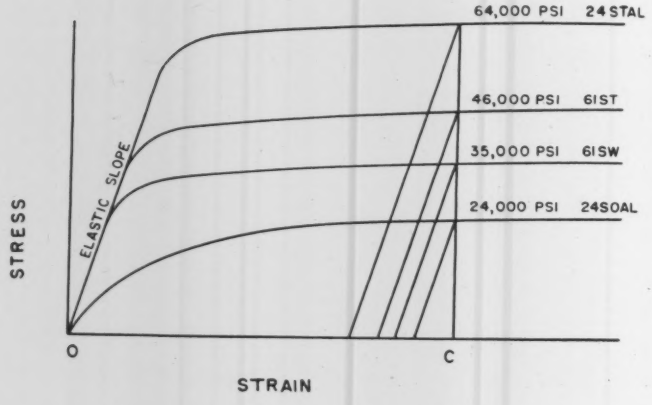

FIG. 11 STUDY OF SPRINGBACK

In a like manner, when a sheet of 24STAL is bent, its outer fibers are strained to an amount *C*, and a stress is induced in them equal to *A*. When the forming pressure is removed, the stress and strain are unloaded along the line *AE*, which parallels the elastic slope to the point of permanent shape. The resulting permanent strain is equal to *OE*, and again the difference between the maximum strain under forming and the permanent strain is called the springback.

Since *AE* and *BD* both parallel the elastic slope, the two triangles *AEC* and *BDC* are similar. From plane geometry, the ratio of *DC*, the 24SOAL springback, to *EC*, the 24STAL springback, is the same as the ratio of the forming stresses which yield the springbacks, namely, the stresses at *B* and *A*.

The angular springback of the bent sheet is directly proportional to this springback *DC* or *EC*, and, by comparing the two, a close approach may be had to the relative angular springback of the two materials.

In order that we may make a comparison of springback, Fig. 11 shows the stress-strain curves for four aluminum alloys 24SOAL, 61SW, 61ST, and 24STAL. In bending a sheet of given thickness over a given radius, a definite strain results. Let us call this strain *C* and consider such a bend for these four materials. The stresses for each material corresponding to the strain *C* appear on the curves. Using 24SOAL as a basis, the ratios of springback should be approximately as follows:

$$\frac{61SW}{24SOAL} = \frac{35,000}{24,000} = 1.5 \qquad \frac{61ST}{24SOAL} = \frac{46,000}{24,000} = 1.9$$

$$\frac{24STAL}{24SOAL} = \frac{64,000}{24,000} = 2.7$$

These figures can be compared favorably with the ratios of actual springback appearing in Table 1. In this table under the actual columns, appear the ratios of actual springbacks taken from formability-test samples. Next to them appear the springback ratios calculated from the stress-strain diagrams. A close correlation can be seen by comparing the two.

TABLE 1 ACTUAL AND PREDICTED SPRINGBACK RATIOS TAKEN FROM STRESS-STRAIN DIAGRAMS

	61SW / 24SOAL		61ST / 24SOAL		24STAL / 24SOAL	
Gages	Actual	Predicted	Actual	Predicted	Actual	Predicted
0.020	...	...	...	...	2.6	2.7
0.032	1.5	1.5	...	...	2.7	2.7
0.040	...	...	1.9	1.9	2.6	2.7
0.051	1.5	1.5	...	...	2.5	2.7
0.064	...	...	2.0	1.9	2.6	2.7

Therefore if the springback of one material is known and comparable springbacks for a new material are desired, the stress-strain diagrams of the two materials will allow a good comparison of their relative springbacks.

The hydropress formability test is relatively simple and its application has, as may be seen from the foregoing, assisted in the solution of various problems of relative formability and substitution of sheet metals.

A possible future application of this test has been pointed out by the recent adoption by the Army and Navy of Material Specification AN-A-13, wherein the thickness of the Alclad coating of certain gages of 24SAL material has been decreased. This, of course, will result in a stronger but slightly less formable material, which will need to be compared with the older, more formable 24S Alclad.

The author hopes that through the presentation of this explanation of the test, engineers dealing with such problems may be inspired to make use of a similar device for predicting the proper uses of sheet metal.

GASKET-LOADING CONSTANTS

A Review of the Gasket-Loading Constants Suggested in Table UA-7 of the A.S.M.E. Unfired Pressure Vessel Code

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THE present Rules for Bolted Flanged Connections of the A.S.M.E. Unfired Pressure Vessel Code have been available for a sufficient length of time to permit appraisal of their worth as a comparator of flanged and gasketed joints of widely differing types. In the estimation of the authors of this review, they have stood the test of usage well, at any rate in the field of intermediate- and high-pressure exchanger and pressure-vessel flanges for which they were primarily intended. Criticism, where it has transcended generalities such as complaints on the complexity of the calculations required, has largely revolved about low-pressure applications; there have been differences of opinion about suitable stresses for carbon-steel bolting and some users have expressed dissatisfaction with the gasket constants published in Table UA-7.

This article will concern itself with the determination of the gasket load only. As now published, the gasket factors are not mandatory; they are suggestive only, a pregnant point which has been strongly emphasized in Note 1 on page 292 of the A.S.M.E. Unfired Pressure Vessel Code. To leave the rules in this form was a wise decision, and a natural one in view of the great complexities attending the proper evaluation of the gasket loading. For the benefit of those users in whose minds the shortcomings of the gasket rules have tended to discredit the entire approach to flange design, a few of the difficulties encountered in framing the rules are enumerated as follows:

1 Notwithstanding the large number of gaskets in everyday use, the mechanics of the action of gaskets is not yet properly understood.

2 Test data as well as correlations of operating records are extremely limited, nor is there a satisfactory basis for mutual comparison.

3 Contributory factors to this confusion are the variety of gasket materials, shapes, thicknesses and widths in use; the diversity of facings employed; the wide variations in flange stiffness; the uncertainties attending the bolt pull-up.

4 Gasket behavior is further affected by the medium contained and the operating pressures and temperatures, as also the extent to which they fluctuate.

From the foregoing it will be evident that the present gasket rules constitute an extreme simplification of a rather complex problem in which only some of the most elementary effects have received consideration. With increasing knowledge, further refinement of the approach should become possible, although it appears impractical to compress all the variables into a few simple factors as now incorporated in the Code without being liable to considerable error in borderline cases; judgment and personal experience will always remain necessary to temper the application of any handbook constants which may be evolved. At the present time, the most urgent need appears to be an examination of the following factors:

1 Yield values for soft gaskets
2 Effects of gasket thickness
3 Effects of gasket width
4 Facing effects as applied to soft gaskets.

In an effort to evaluate these effects and bring the gasket design data into better accord with known safe performance, the authors have reviewed the miscellaneous experimental and service data which had accumulated in their files over the years; in view of the present situation which demands the use of the lighest-weight flanges which can be justified, a liberal interpretation has been placed on these data. The values finally selected are set down in the form of tables paralleling the present Code Tables UA-7A and B which are reproduced herein. The purpose of their publication is to stimulate free discussion by engineers interested in the manufacture and use of gaskets which, it is hoped, will lead to a better understanding of the entire subject.

Two significant changes have been made in Table A which lists the gasket factors and yield values:

1 The materials list has been further subdivided; in particular, separate design values are assigned to different thicknesses of one and the same gasket material, in recognition of the very pronounced effect of thickness, particularly in the case of the softer gaskets.

2 The yield values have been adjusted, the relatively well-established values for solid metals being retained while those for the softer gaskets are reduced; the yield value for gum rubber, which is practically self-sealing, has been reduced to zero from 500 psi; an empirical formula, $y = 180(2m\text{-}1)^2$, has been used to give a correlation between suitable values of the gasket factor m and the so-called yield value y.

Table B, relating to the gasket yielding width and location of load attack, contains three innovations which primarily affect the softer materials:

1 Two columns are shown for the "basic" gasket yielding width, of which the first, substantially following the present rules, applies to solid metal gaskets only, while the second, providing a reduced credit for nubbins or serrations, applies to softer types of gasket where special facings have been found to be less effective.

2 Where the "basic" gasket yielding width b exceeds $1/4$ in., the "effective" gasket yielding width b_0 is established as one half the square root of the "basic" width b calculated in inches. Limited tests made specifically for the purpose of evaluating the effect of gasket width appear to substantiate a rule of this type which affords considerable relief in the case of very wide gaskets as are often used in low-pressure applications.

3 The gasket load is applied along a circle of diameter G equal to the outside gasket (contact) diameter less twice the yielding width b. This moves the point of load attack closer to the bolts in the case of wide gaskets, while in the case of narrow gaskets, as also such used with facings concentrating the gasket load at a predetermined line, the gasket reaction remains at the center of the gasket width as now specified in the Code.

In order to give those interested in applying the modified gasket rules to specific cases an opportunity to test the results against their experience, we have calculated a few typical low-pressure installations using the new assumptions; the ex-

TABLE A: GASKET FACTORS m AND YIELD VALUES y

GASKET MATERIAL		GASKET FACTOR m	YIELD VALUE y	SKETCH & NOTES	REFER TO TABLE B: FACING LIMITATION	USE COL.
GUM RUBBER SHEET		.50	0		USE ①④⑥ ONLY	II
HARD RUBBER SHEET		1.00	180			
CLOTH INSERTED SOFT RUBBER		.75	50			
CLOTH INSERTED HARD RUBBER		1.25	400			
VEGETABLE FIBRE SHEET (HEMP OR JUTE)		1.75	1120			
RUBBERIZED WOVEN WIRE INSERTED ASBESTOS	3-PLY	2.25	2200			
	2-PLY	2.50	2880			
	1-PLY	2.75	3650			
ASBESTOS COMPOSITION OR COMPRESSED ASBESTOS	1/8" THICK	2.00	1620		USE ①④⑥ ONLY	
	1/16" THICK	2.75	3650			
	1/32" THICK	3.50	6480			
SPIRAL-WOUND METAL, ASBESTOS FILLED	CARBON STEEL	2.50	2880			
	KA2S OR TYPE 316	3.00	4500			
SERRATED STEEL, ASBESTOS FILLED		2.75	3650			
CORRUGATED METAL, ASBESTOS INSERTED OR CORRUGATED METAL JACKET, ASBESTOS FILLED	SOFT ALUMINUM	2.50	2880		USE ① ONLY	
	SOFT COPPER OR BRASS	2.75	3650			
	IRON OR SOFT STEEL	3.00	4500			
	MONEL OR 4-6% CHROME	3.25	5450			
	11-13% CHROME, KA2S OR TYPE 316	3.50	6480			
CORRUGATED METAL	SOFT ALUMINUM	2.75	3650			
	SOFT COPPER OR BRASS	3.00	4500			
	IRON OR SOFT STEEL	3.25	5450			
	MONEL OR 4-6% CHROME	3.50	6480			
	11-13% CHROME, KA2S OR TYPE 316	3.75	7600			
FLAT METAL JACKET, ASBESTOS FILLED	SOFT ALUMINUM	3.25	5450			
	SOFT COPPER OR BRASS	3.50	6480			
	IRON OR SOFT STEEL	3.75	7600			
	MONEL OR 4-6% CHROME	4.00	8820			
	11-13% CHROME, KA2S OR TYPE 316	4.25	10120			
GROOVED IRON OR SOFT STEEL CORE, METAL JACKETED	SOFT ALUMINUM	3.25	5450		USE ①④⑥ ONLY	
	SOFT COPPER OR BRASS	3.50	6480			
	IRON OR SOFT STEEL	3.75	7600			
	MONEL OR 4-6% CHROME	4.00	8820			
	11-13% CHROME, KA2S OR TYPE 316	4.25	10120			
SOLID METAL, 1/8" THICKNESS OR MORE (FOR THINNER GASKETS SEE NOTE)	SOFT ALUMINUM	4.00	8820	NOTE: FOR EACH 1/32" REDUCTION IN THICKNESS BELOW 1/8" INCREASE m BY .25, COMPUTE $y = 180(2m-1)^2$		I
	SOFT COPPER OR BRASS	4.75	13000			
	IRON OR SOFT STEEL	5.50	18000			
	MONEL OR 4-6% CHROME	6.00	21780			
	11-13% CHROME, KA2S OR TYPE 316	6.50	25920			

TABLE B: EFFECTIVE GASKET WIDTH b

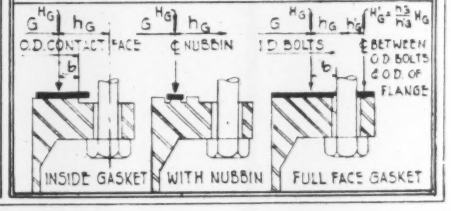
FACING SKETCH	BASIC GASKET YIELDING WIDTH b_o COL. I	COL. II
(1a)	$\frac{n}{2}$	$\frac{n}{2}$
(1b)	$\frac{w+t}{2}\left(\frac{w+n}{4}\text{ max}\right)$	$\frac{w+t}{2}\left(\frac{w+n}{4}\text{ max}\right)$
(2)	$\frac{w+n}{4}$	$\frac{w+3n}{8}$
(3)	$\frac{w}{2}; \left(\frac{n}{4}\text{ min}\right)$	$\frac{w+n}{4}; \left(\frac{3n}{8}\text{ min}\right)$
(4) (5)	$\frac{3n}{8}$	$\frac{7n}{16}$
(6) (7)	$\frac{n}{4}$	$\frac{3n}{8}$
(8)	$\frac{w}{8}$	

EFFECTIVE GASKET YIELDING WIDTH b

$b = b_o$, when $b_o \leq 1/4"$

$b = \frac{\sqrt{b_o}}{2}$, when $b_o > 1/4"$

LOCATION OF GASKET LOAD ATTACK

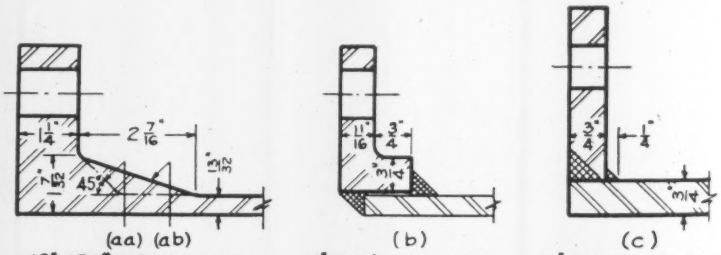


amples chosen are illustrated in Fig. 1 together with the resultant bolt and flange stresses. In order not to obscure the comparison, the moments have in all cases been computed for the "required" bolt load W_m obtained in accordance with the rules of Par. UA-20(a), rather than the "design" bolt load W.

For full-face gaskets, the magnitude of the reaction of the gasket to the outside of the bolt holes has been so determined that the moments due to the internal and external gasket loads are balanced about the bolt circle. With this assumption, the gaskets do not contribute to the moment causing flange rotation, which then simply becomes $M_0 = M_D + M_T$ in the terms of the Code.

As an interesting side light, attention is directed to the parallel calculations applying to sketches (aa) and (ab) which, respectively, represent approximate minimum and maximum hub taper lengths furnished when specifying flanges to A.S.A. Standard B16e. For the latter, the stresses remain moderate; the variant with the short 45-deg taper hub, on the other hand, shows high hub stresses. This illustrates the need for standardization of the hub proportions before ratings consistent with present-day flange design can be assigned to A.S.A. flanges.

Example (c), referring to a manhole to A.P.I. Standard 12-C, is included to show that the A.S.M.E. Code method of flange design is applicable over a wide range of flange proportions and service conditions. While the calculated stresses in the carbon-steel bolting and the flange are somewhat higher than permitted in the A.S.M.E. Code, it must be remembered that the A.P.I. Standard allows 21,000 psi stress for 55,000 UTS plate material, on which basis the manhole flange would be comparable in strength to the shell.



SKETCH	ASBESTOS COMPOSITION GASKET	FOR INT. PRESSURE (PSI)	BOLT STRESS (PSI)	LONG. HUB STRESS (PSI)	RAD. FLG. STRESS (PSI)	TANG. FLG STRESS (PSI)
(aa)	FULL FACE 19"×11 15/16"×1/8"	230	18,500	15,800	6,000	3,800
(aa)	INSIDE ONLY 16"×11 15/16"×1/16"	230	17,100	25,000	9,600	6,000
(ab)	FULL FACE 19"×11 15/16"×1/8"	230	18,500	4,300	6,800	2,000
(ab)	INSIDE ONLY 16"×11 15/16"×1/16"	230	17,100	6,800	10,700	3,200
(b)	FULL FACE 19"×12 7/8"×1/8"	75	15,500	2,600	6,300	5,100
(b)	INSIDE ONLY 16"×12 7/8"×1/8"	75	6,800	4,500	10,900	8,900
(c)	INSIDE ONLY 29 3/8"×24"×1/8"	34	9,900	10,900	15,500	3,000

FIG. 1

The AIR-TRANSPORT MARKET *in* LATIN AMERICA

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MARKET OR MIRAGE?

IN present considerations of postwar market possibilities, the potentialities of the twenty Latin-American republics are generally spoken of in glowing terms. In addition to extolling the "good-neighbor policy," there is a noticeable tendency to assume an almost unlimited market to the south of us following the war, eagerly awaiting American products.

There can be no question that commercial relations between Latin America and the United States have, in general, greatly improved during recent years, and that a far larger market exists in that area for us than ever before in history. It may be worth while, however, to examine some of the factors which may determine the extent of that immediate postwar market, particularly with regard to the use of American air-transport equipment.

BACKGROUND OF THE MARKET AREA

Consider first of all the general characteristics of Latin America: From the Rio Grande to the Straits of Magellan is some 6000 miles. East and west across the South American continent at its widest point is about 3000 miles. The total area, including Middle America, is some two and one-half times larger than the United States, or roughly 8,000,000 square miles. Its population of 128,000,000 is composed of about 26,000,000 whites, the remainder being pure Indians, negroes, and mestizos. Of the ten republics of the South American continent, one alone, Brazil, is bigger in area than the United States. The continent has the smallest population and lowest density per square mile of any continent except Australia. It is still primarily dependent upon agriculture and mining. Raw materials form the bulk of its exports.

In every country, almost without exception, nature has placed serious obstacles to surface transportation. From one end of the area to the other a mountain wall runs, almost like a spinal column, interposing a barrier to east-west travel. This great mountain wall, marked by peaks rising to above 20,000 feet in Ecuador, Peru, Bolivia, Argentina, and Chile, is Latin America's most prominent feature. Elsewhere, great swampy river basins, extensive tropical jungles, and barren deserts add further obstacles to ground transportation. Surface lines of communication for the most part are limited to the coastal region. Lacking adequate transportation facilities, the hinterlands still remain largely undeveloped and inaccessible. To this combination of geographical obstacles and limited surface communication, the airplane owes its unequaled opportunity for usefulness.

COMPARISON OF AIR AND SURFACE TRAVEL

Even on principal trade routes between neighboring capitals, the airplane offers impressive advantages. On the east coast of South America, for example, from Buenos Aires, Argentina, to Rio de Janeiro, Brazil, surface travel requires six days, against seven hours by plane. From Rio inland to Asuncion, the neighboring capital of Paraguay, it is a 10-day ground trip; by air, six hours. On the west coast, from Lima, capital of Peru, 1650 miles to Santiago, Chile, the surface trip requires about six days, against 10 hours by air.

Off-Line Routes. Once one leaves the main trade routes, the comparison is still more startling. Not only is surface land travel often incredibly slow, irregular, and uncomfortable, but at times even dangerous. Further, the gross cost is sometimes higher than the corresponding air-line fare.

Consider, for example, the 85-mile route between Cuenca and Loja in southern Ecuador, where a link of the Pan American Highway is now being pushed to completion. Cuenca is an important source of Panama hats, and Loja is an agricultural and textile center. To journey between the two towns takes five days by mule over a cold and wind-swept mountain trail with little or no provision for overnight lodging. Mule hire alone is $10, exclusive of shelter and food.

Panagra makes the flight three times a week in 45 minutes and charges $12. Thus, even at a rate equivalent to 14½ cents per passenger-mile, the air line has little surface competition.

Taking another example, that from Lima, capital of Peru, to Iquitos in the northeast corner of the country, on the upper waters of the Amazon River basin, the direct air distance is some 735 miles. With modern equipment a three- to four-hour air-line schedule is entirely practicable (although no direct service is presently operating). Other than by plane the normal mode of travel between Lima and Iquitos is by boat through the Panama Canal, around South America and back up the Amazon River, an 8000-mile journey involving 30 to 40 days. The boat fare is approximately $450, which on the direct air route would be equivalent to about 60 cents per passenger-mile. An alternative overland route is the difficult Pichis Trail, employing successively automobile, mule, balsa raft, and launch, and requiring some 25 to 30 days.

EXISTING AIR-LINE NETWORK

In view of such tremendous advantages offered by air travel, it is not very surprising that 107,000 miles of air-line routes have developed throughout Latin America during the past 15 years. Forty air-transport companies operate in this area, employing some 250 multiengine planes, with scheduled stops at about 555 communities.

Almost all the principal cities are served and, in addition, many smaller towns and even haciendas, particularly in Central America and Mexico. The proportion of Latin Americans living in cities, however, is quite small. The nonurban population is widely scattered, and probably not more than one fifth of the total population can be considered as actually within reach of direct air-line service.

While this network of air routes is over twice as great as our own domestic system, the volume of traffic moving over it is very much less. This is perhaps to be expected when a comparison is made of the standards of living generally prevailing in the United States, and among the 128,000,000 inhabitants of Latin America.

In 1940, for example, passenger traffic was 17 per cent and mail traffic 6 per cent of the U. S. domestic system. The total miles flown were only about one fourth those of our domestic air lines. But the pounds of cargo carried by the Latin-Ameri-

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can system as a whole was some six and a half times greater. Almost one third of this air-freight traffic (on a ton-mile basis) was carried by one operator alone, TACA, in Central America.

For a more detailed account of the entire Latin-American air-line development, an excellent book[1] which has just been published by the Council on Foreign Relations is recommended. The book is a veritable mine of authoritative information on all phases of Latin-American aviation, and the author has drawn on it freely in preparing this paper.

Each of the 40 air lines composing the Latin-American air-transport system presents an interesting and important story. Four of them have been chosen for brief review, in order to give a better perspective of Latin-American market possibilities.

Linea Aerea Nacional (LAN-Chile). LAN of Chile, for example, is a wholly owned government operation. It has a monopoly on air transportation within Chile, as Panagra, which parallels much of its route, does not have cabotage rights in that country.

Originally, its equipment was French and German, dating back to 1929; but, in 1941, it purchased six Electras from Lockheed. Primarily with this new equipment, it has been able to establish excellent local service for 1300 miles along the Chilean coast, from Arica at the Peruvian border, to Concepcion, well south of Santiago. As of January 1, 1942, the aircraft fleet consisted of six Electras and three Potez 6-passenger planes equipped with Jacobs engines.

LAN is one of the few remaining air lines to obtain its air-mail revenues by issuing its own air-mail stamps.[2] The post office sells the stamps for the account of the air line, retaining only a small service charge. The unit postal rate is fairly high, equivalent to 8 cents U. S. currency for one third of an ounce.

Its operating revenues for 1941 are shown in Table 1. Excluding the direct subsidy, the commercial revenue is approximately 40 cents per mile flown, of which a little less than two thirds is derived from passengers, and one fifth from mail. Passenger fares are relatively low, being equivalent to 4.3 cents in U. S. currency. Operating costs were reported in the neighborhood of 54 cents per mile.

TABLE 1 OPERATING REVENUES IN 1941 OF LINEA AEREA NACIONAL

	Cents per mile (U. S. currency)		In per cent of commercial revenue	
Passengers	23.3		58.0	
Express	3.1		7.7	
Mail	8.1		20.2	
Miscellaneous	5.7		14.1	
Commercial revenue		40.2		100.0
Direct subsidy	62.8		156.0	
Total operating revenues		103.0		256.0
(Reported operating profit	45.7)			

Aircraft fleet, Dec., 1941: 6 Lockheed Electras and 3 Potez-Jacobs 225 hp).

Average passenger revenue per passenger-mile: 4.3 cents.

Linea Aeropostal Venezolana. Another interesting wholly owned government operation is LAV, of Venezuela, a company organized 10 years ago when the government nationalized the old French Compagnie Generale Aeropostale.

LAV began operations with the three single-engine 8-passenger Latecoere planes acquired from its predecessor company. By 1939, the original French equipment had been retired, and the company now operates a fleet of 10 planes (including one ambulance plane), consisting almost entirely of Lockheed aircraft, principally Electras.

TABLE 2 OPERATING REVENUES IN 1941 OF LINEA AEROPOSTAL VENEZOLANA

	Cents per mile (U. S. currency)		In per cent of commercial revenue	
Passengers	64.8		60.3	
Express, freight, and baggage	27.5		25.6	
Mail	15.2		14.1	
Commercial revenue		107.5		100.0
Direct subsidy	..		...	
Total operating revenues		107.5		100.0
(Reported operating profit	17.5)			

Aircraft fleet, Dec., 1942: 6 Lockheed Electras, 2 Lockheed 14's, 1 Lodestar.

Average passenger revenue per passenger-mile: 14 cents.

Its operating revenues for 1941 are shown in Table 2. No direct subsidy is paid. An operating profit of 17.5 cents per mile was reported in 1941. While its revenue from mail is substantial, this is only about 20 per cent of what the government receives from the mailing public from the sale of air-mail postage.

LAV'S passenger revenues (when translated into U. S. currency) of 14 cents per passenger-mile are among the highest in the Western Hemisphere. This rate, however, must be interpreted in terms of the relative value of the Venezuelan bolivar and the U. S. dollar. Venezuela is one country in which our currency is substantially depreciated. If the 14-cent passenger fare is adjusted in proportion to the special allowance received by U. S. representatives on duty there, the resulting equivalent is about $8\frac{1}{2}$ cents per passenger-mile.

Similarly, the reported operating expense of 90 cents per plane-mile is equivalent, on an adjusted dollar basis, to about 55 cents, or almost identical with that reported by LAN-Chile, using largely the same type of equipment, flying about the same intensity of service (100,000 miles per year per plane).

Viacao Aerea Sao Paulo. The State of Sao Paulo, in Brazil, holds controlling interest in an interesting little air-line operating principally between the industrial cities of Sao Paulo and Rio de Janeiro, an air-line distance of 224 miles.

Eighty-five per cent of VASP's commercial revenue is from passengers, as shown in Table 3. A modest subsidy provided largely by the state made it possible to report a small operating profit in 1941. The average passenger revenue, translated into U. S. currency, was 4.2 cents per passenger-mile.

TABLE 3 OPERATING REVENUES IN 1941 of VIACAO AEREA SAO PAULO

	Cents per revenue mile (U. S. currency)		In per cent of commercial revenue	
Passengers	57.0		84.4	
Express, freight, and baggage	5.5		8.2	
Mail	5.0		7.4	
Commercial revenue		67.5		100.0
Direct subsidy	11.0		16.3	
Total operating revenues		78.5		116.3
(Reported operating profit	2.0)			

Aircraft fleet, June, 1941: 5 Trimotor 17-passenger Junkers JU-52.

Average passenger revenue per passenger-mile: 4.2 cents.

The fleet consists of five JU-52 17-passenger planes, and the service has been maintained with a high degree of regularity and safety. Only one serious accident has occurred in 9 years of operation.

Sao Paulo and Rio each have between 1,000,000 and 2,000,000

[1] "The Struggle for Airways in Latin America," by W. A. M. Burden, Special Aviation Assistant to the Secretary of Commerce, Council on Foreign Relations, New York, N. Y., 1943.

[2] Avianca, in Colombia, is the only other company in the Western Hemisphere which has a monopoly on the sale of air-mail stamps. The unit air-mail rate in Colombia is the highest in Latin America, equivalent to 12 cents U. S. currency. A unit weight of 20 g, or approximately $\frac{2}{3}$ oz, is allowed, however. In many other countries with lower initial charges, the unit of weight is only 5 g, or about $\frac{1}{6}$ oz. (Ibid., table 27, p. 111.)

population. The four air lines operating between them supply a total of 40 round trips a week. Nevertheless, the route can undoubtedly support a much greater intensity of operation, judging by the frequency of service on U. S. domestic routes connecting similar cities with comparable intercity surface transport facilities. This same comment holds true for several other Latin-American routes, assuming of course reasonable fares, efficient service, and aggressive traffic promotion.

Compania de Aviacion "Faucett," S. A. An entirely different type of operation is the privately owned Peruvian air line organized in 1928 by Elmer Faucett, a United States citizen. Using single-engine 7-passenger planes built (under Stinson license) in the company's local plant in Lima, this company has operated profitably without subsidy for 15 years or more.

Faucett's low operating costs, as shown in Table 4, may be

TABLE 4 OPERATING REVENUES IN 1941 OF COMPANIA DE AVIACION "FAUCETT," S.A.

	Cents per revenue mile (U. S. currency)	In per cent of commercial revenue
Passengers and baggage	14.9	54.8
Express and freight	5.8	21.3
Mail	3.1	11.4
Other commercial	3.4	12.5
Commercial revenue	27.2	100.0
Direct subsidy	..	.....
Total operating revenues	27.2	100.0
(Reported operating profit	5.0)	

Aircraft fleet, Nov., 1942: 8 Faucett 7-passenger, single P.&W. engine.

Average passenger revenue per passenger-mile: 4.0 cents.

one reason. Passenger revenues average 4 cents per passenger-mile. A substantial business in express and freight has been built up, particularly on charter flights across the Andes.

The fleet, as of the end of 1942, consisted of eight Faucett planes, equipped either with a 600-hp Wasp or 875-hp Hornet engine. This year Faucett is also operating three amphibian planes between the upper Amazon Basin and the Pacific Coast, under contract with the U. S. Rubber Development Corporation.

One reason why Faucett's single-engine operations have proved so successful is because of the peculiar weather and topographical aspects of Peru. Twenty per cent of the population lives along the narrow coastal plain between the foothills of the Andes and the Pacific Ocean. This littoral is in large part a shrubless desert sliced by some 50 rivers, few of which reach the sea. Although only 12 deg below the equator, the climate of Lima is as mild as and somewhat similar to that of San Francisco.

This is largely due to the influence of the Humbolt Current, which flows northward along the Pacific Coast and tempers the weather along the entire Peruvian littoral. It also often brings a blanket of clouds that forms along the coast and characteristically extends a few miles inland, from June to December. Save for this persistent cloud bank, coastal flying weather is ideal.

The length of this narrow coastal strip is 1400 miles, roughly equivalent to that from Chicago to Key West. Twenty miles east of Lima, however, the foothills of the Andes begin; and while the distance to the Brazilian border eastward from Lima is no farther than from New York to Pittsburgh, the pass over the Andes is 7 times higher than the crossing over the Alleghenies.

POSTWAR MARKET POSSIBILITIES

With this sketchy picture of Latin-American operations for background, let us consider briefly some aspects of the postwar air-transport market in the area. In this connection, it will help to follow the division suggested by Mr. Burden, between international trunk routes and the local network.[1]

International Trunk Routes. The war, of course, has tremendously accelerated the growth of air travel between the United States and Latin America, as well as within the 20 republics. By the end of the war, the volume of air service between the Americas may be several times what it was at the beginning of 1941.

It is certainly reasonable to suppose that great numbers of travelers who have grown accustomed to flight under emergency conditions will not return to boat transportation after the war. Great as the potential expansion is in the intercontinental field, however, it is possible to foresee certain definite limitations, at least in the immediate postwar years.

At the end of 1940, for example, there were 58 twin-engine and 10 four-engine transports in service on Pan American's Latin-American system. The average utilization of this equipment, on the Panagra portion at least, was less than three hours a day. Yet the amount of traffic, in proportion to existing surface travel, which the trunk lines were carrying was already surprisingly high.

Traffic and Fares. Mr. Burden estimates, for the fiscal year 1940, that passenger traffic by air between the United States and Latin America was already equal to about 11 per cent of steamship traffic.[3] The poundage of intercontinental trunk line mail was equal to 29.5 per cent of the surface mail between the United States and Latin America. Commodity traffic, however, was only an infinitesimal fraction of the total cargo transported between the Americas.

One-way passenger fares on the trunk routes averaged over $10^1/_2$ cents per passenger-mile. Postal rates were some 26 times surface mail rates; while express rates at 80 cents to $1.30 per ton-mile averaged roughly 150 times steamship rates.

We may assume that these rates can be very substantially reduced in the postwar period. We may also expect to see the introduction of larger planes, faster schedules (including night flying), increased frequencies, and aggressive traffic promotion.

If under these assumptions a total business equivalent to 100 per cent of 1940 surface travel should develop, the resulting intercontinental traffic would represent on the order of 350,000,000 passenger-miles of air travel and some 2,000,000 ton-miles of mail. This, however, is only equivalent to one fourth of the passenger-miles and one eleventh of the mail ton-miles of service performed by United States domestic air carriers with some 200 planes of DC-3 capacity during the calendar year 1942.

Mr. Burden has made the interesting suggestion[4] that the U. S.-owned system in Latin America might be operated along three basic routes, each from a United States terminus; one down the East Coast, another down the West Coast, and a third running down the center of the continent; each with its connecting feeders. Even under the stimulation of such indirect competition, however, the principal source of a really substantial market appears to lie in diverting to air transportation some of the tremendous flow of goods between the two continents. This means cargo planes designed for low-cost transportation.

The Local Network. Granted favorable technical, political, and financial conditions, there is a great field for the development of internal air transportation in Latin America. Air travel in general represents far more than an improvement over existing services. In effect, it offers an entirely new kind of transportation.

A tremendous shortage of air transportation exists. Con-

[3] Reference 1, p. 136. In addition to intercontinental passenger traffic, it is estimated that there was about an equal amount of internal traffic carried on Pan-American trunk lines.

[4] Reference 1, p. 154.

tacts, hitherto impossible between coastal and hinterland regions, become commonplace by plane. In as country a young as Latin America in an economic sense, the coming of the "Air Age" portends vast social and political changes.

Amazon Basin. An interesting example of this may be seen in the program which the governments of the United States and of the South American countries, in whose territory the Amazon Basin lies, have under way for increasing the production of rubber. This development will involve one of the greatest mass migrations of history, perhaps half a million persons in all, who must be distributed over an area two thirds the size of the United States.[5] The program includes the widespread use of planes to transport doctors, distribute medical assistance, and provide an adequate food supply. The convenient and flexible air-transport service thus developed in what is perhaps one of the largest and richest unexplored areas remaining in the world, will undoubtedly be perpetuated on one basis or another after the war.

In the mountainous sections of Latin America, too, the airplane can perform a vitally needed service. In these isolated areas, often the only transportation is by mule, at costs equivalent to 30 cents or more per ton-mile.

TACA has shown the potentialities in this field, through its remarkable pioneering operations in Central America. In the spring of 1941, its flight equipment consisted of some 50 planes, which served 236 points in the several Republics north of the Panama Canal, the average distance between airports being about 50 miles.

In 1941, TACA carried some 30,000,000 pounds of express and freight, including such articles as fresh butter, meat, vegetables, galvanized iron, tobacco, and all types of mining machinery. Operating on the principle of deferred freight at low rates, TACA has been able to keep its planes loaded close to capacity on almost every run.[6]

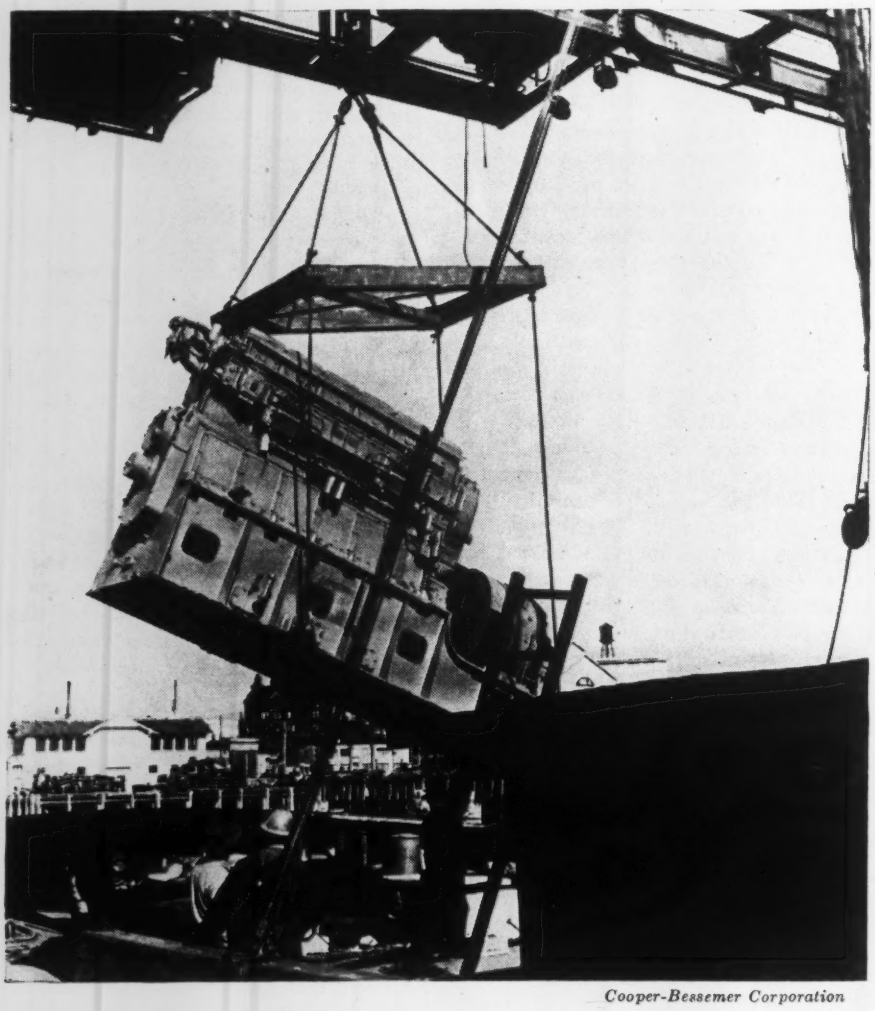
Any estimate of the postwar market in this field must take account of complex diplomatic considerations and nationalistic tendencies, where 20 sovereign states are involved. Government policies toward commercial aviation may well be the controlling factor in the future growth of Latin-American air transportation.

The inauguration of a comprehensive airport program, the development of adequate airway and meteorological facilities, and the adoption of liberal subsidy and regulatory policies will go far toward ushering in a new era of transportation throughout Latin America.

Granted this favorable premise, the dynamic expansion of air-transport operations which will follow will make even the tremendous development of the past 15 years pale into insignificance.

[5] Reference 1, pp. 77, 185.

[6] Obliged, like Faucett in Peru, to justify itself economically in order to survive, TACA has operated profitably without subsidy for years. A standard of service well adapted to local needs has contributed to its success. In 1940, 60 per cent of TACA's income was from freight, 31 per cent from passengers; 5 per cent from mail.



Cooper-Bessemer Corporation

LOWERING A SIX-CYLINDER DIESEL ENGINE INTO A SALVAGE VESSEL

Problems Affecting the Use of WOOD *in* AIRCRAFT

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INTRODUCTION

THE current use of wood in aircraft presents little that is distinctly new. Wood airplanes, including some with plywood skins, were built prior to, during, and following the last war. Even the art of molding plywood to shape, either following or preceding the bonding of the veneers, is not new either to the aircraft or to the wood industry.

Many advancements in methods and a great improvement in the quality of finished product have taken place. Designs have moved somewhat farther toward more efficient use of wood properties, a little farther away from "conventional" design. Many new adhesives have appeared but their use does not change the fundamentals of airplane construction. The resin adhesives now available permit much greater flexibility in fabrication methods, permit high-speed production schedules, and promise much greater durability. Although they have not reached the efficiency we had hoped for, wood finishes have improved considerably. With definite improvements in design, fabrication methods, adhesives, and finishes there remains only one other major component in the wood airplane.

At first thought it might seem that there is little that can be done to improve materially the quality of wood used. Certainly the trees grow no better than they did 25 years ago. There are, however, many ways in which we can assure delivery of a higher-grade wood material to the consumer.

The author believes that the wood industry itself has done more to prevent the expansion of wood uses and has done less to develop permanent acceptance of wood in highly competitive uses than has any other comparable material producer. It is true that many advancements have been made in the face of a number of well-known handicaps, but it will not suffice, in the present and coming competitive periods, to rest on the laurels obtained by standardization of grade rules and maintenance of low price levels. Wood industries must not forget that product improvement is a major weapon in the hands of their competitors and, although little used, is available for use with wood materials and wood products.

Many of the problems now confronting the wood-aircraft manufacturer can be solved by the wood industries, or in cooperation with them, and most of these problems fall essentially in a wood-product improvement field.

QUALITY OF MATERIAL

Specific-gravity control is important from a weight standpoint and also for accurate strength determinations. Weight, of course, is essentially synonymous with density. Fortunately there is also a direct relationship between strength and specific gravity within a species. The permitted range of specific gravities of aircraft woods is about 20 to 28 per cent from minimum to maximum. Most of the essential strength properties will vary in a similar or slightly greater ratio.

Reduction of these extremes of variation to a more efficient minimum requires source or raw-material control. Division of the material into two specific-gravity groups, high and low, would be the most efficient method but also the most difficult. Further restriction of the high and low values would be the easier method but would exclude much otherwise suitable material.

In practice, sorting of sliced veneer into specific-gravity classes would probably require cutting two or three blocks from the stay-log board after slicing has been completed. The blocks cut from different positions across the board would represent the variation of specific gravity across the veneer sheet. The average specific gravity of these blocks could be determined within a relatively short time after the veneer leaves the driers and is packaged or racked. Rotary-cut veneer would require periodic sampling of the sheet, probably at the clipper.

With the wood sorted into two specific-gravity groups, the designer would be able to determine structural strengths within ± 5 per cent rather than ± 10 per cent as he does now. The tolerances permitted is another major variable affecting the uniformity of wood structures. The thicknesses generally involved in the use of solid wood tend to reduce the effect of the usual tolerances to a minimum. In veneer which is to be used for thin plywood, however, the tolerances become appreciable.

The average veneer tolerance permissible under the Army-Navy "Aircraft Flat Panel Plywood Specification," AN-NN-P-511b, is about ± 10 per cent. This is considerably more than comparable metals, although the differences in density will permit roughly 4 to 5 times as much dimensional variation in wood as is permissible in aluminum with similar weight and most strength effects. A very considerable reduction of required tolerances in veneer thicknesses is conceivably possible with adequate equipment and careful process control. Under the present requirements for very large volume production, it probably is not feasible to request this improvement but it is reasonable to expect that eventual reductions can be obtained, thus further reducing strength and weight variations of the wood structures.

The problem of moisture absorption and moisture-content control continues to be a deterring factor in the use of wood in aircraft. Complete general control has not yet been achieved by all the veneer, plywood, or aircraft manufacturers. The problem can be readily overcome by maintaining a reasonably uniform moisture content throughout the entire manufacturing process. Thus stabilized, pieces can be bonded together without subsequent stress, component parts made to pattern will fit under any given uniform moisture condition, and the complete airplane will shrink and swell in unison without undue stress. The problem of moisture control is, but should not be, a factor in the control of wood quality.

BASIC-DATA ACCUMULATION AND ANALYSIS

The basic data that are available on wood have not been completely analyzed and correlated for highly stressed uses where weight is important. In order to determine the comparative merits of various woods, thirty five of the more common and abundant species were selected for examination. The ratios of their various strength properties to their weights (specific gravity) were arranged in numerical sequence. Some astonishing comparisons became apparent, indicating that a number of

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TABLE 1 WOODS RATED ACCORDING TO ELASTIC MODULUS-SPECIFIC GRAVITY RATIO

(Static bending)

No.	Species	Elastic modulus-specific gravity ratio, 10^5	Percentage of no. 1
1	Douglas fir[a]	384	100
2	Fir, noble[a]	346	90.1
3	Cedar, Port Orford	345	89.8
4	Red cedar, western	327	85.2
5	Spruce[a]	325	84.6
6	Redwood	319	83.1
7	Magnolia	318	82.8
8	Basswood	313	81.5
9	Pine, western white	312	81.3
10	Pine, Norway	306	79.7
11	Hickory, shagbark	306	79.7
12	Yellow poplar[a]	301	78.4
13	Hemlock, western[a]	300	78.1
14	Pine, ponderosa	300	78.1
15	Maple, soft	298	77.6
16	Balsa[a]	296	77.1
17	Cottonwood, eastern	278	72.4
18	Pine, sugar	275	71.6
19	Mahogany, African[a]	272	70.8
20	Persimmon	272	70.8
21	Walnut, black[a]	267	69.5
22	Sycamore	263	68.5
23	Birch[a]	262	68.2
24	Pecan	250	65.2
25	Mahogany, American[a]	247	64.4
26	Sweetgum[a]	244	63.5
27	Elm, American	243	63.3
28	Gum, tupelo	242	63.0
29	Maple, hard[a]	239	62.3
30	Ash, white	235	61.2
31	Beech, American	218	56.8
32	Gum, black	218	56.8
33	Oak, red	217	56.5
34	Oak, white	217	56.5
35	Willow, black	175	45.6

[a] Woods commonly used in aircraft.

TABLE 2 WOODS RATED ACCORDING TO MODULUS OF RUPTURE-SPECIFIC GRAVITY RATIO

(Static bending)

No.	Species	Modulus of rupture-specific gravity ratio, 10^2	Percentage of no. 1
1	Hickory, shagbark	306	100
2	Cedar, Port Orford	250	81.7
3	Pine, Norway	245	80.0
4	Maple, soft	244	79.6
5	Fir, noble[a]	242	79.1
6	Walnut, black[a]	240	78.5
7	Ash, white	240	78.5
8	Persimmon	240	78.5
9	Redwood	238	77.8
10	Spruce[a]	235	77.0
11	Magnolia	230	75.2
12	Hemlock, western[a]	230	75.2
13	Red cedar, western	229	74.9
14	Mahogany, African[a]	229	74.9
15	Birch[a]	228	74.5
16	Mahogany, American[a]	227	74.2
17	Douglas fir[a]	226	73.9
18	Maple, hard[a]	224	73.3
19	Pine, western white	221	72.4
20	Pine, ponderosa	219	71.5
21	Sweetgum[a]	219	71.5
22	Basswood	217	71.0
23	Beech, American	215	70.4
24	Elm, American	214	70.0
25	Pine, sugar	211	69.0
26	Yellow poplar[a]	210	68.5
27	Oak, red	200	65.4
28	Oak, white	200	65.4
29	Cottonwood, eastern	200	65.4
30	Pecan	198	64.8
31	Sycamore	185	60.5
32	Gum, tupelo	184	60.1
33	Gum, black	174	57.2
34	Balsa[a]	155	50.6
35	Willow, black	151	49.4

[a] Woods commonly used in aircraft.

NOTE: Since modulus of rupture is used for tension parallel to grain, approximately the same order holds for the latter.

TABLE 3 WOODS RATED ACCORDING TO FIBER STRESS IN BENDING-SPECIFIC GRAVITY RATIO

(Static bending)

No.	Species	Fiber stress in bending-specific gravity ratio, 10^2	Percentage of no. 1
1	Pine, Norway	185	100
2	Walnut, black[a]	182	98.5
3	Mahogany, American[a]	173	93.6
4	Cedar, Port Orford	168	90.9
5	Redwood	164	88.8
6	Mahogany, African[a]	163	88.2
7	Maple, soft	158	85.5
8	Douglas fir[a]	157	85.0
9	Fir, noble[a]	157	85.0
10	Spruce[a]	155	83.9
11	Magnolia	154	83.4
12	Pine, ponderosa	150	81.1
13	Hemlock, western[a]	150	81.1
14	Red cedar, western	150	81.1
15	Hickory, shagbark	148	80.1
16	Persimmon	147	79.5
17	Pine, sugar	147	79.5
18	Ash, white	143	77.4
19	Pine, western white	143	77.4
20	Sweetgum[a]	142	76.9
21	Maple, hard[a]	142	76.9
22	Basswood	140	75.8
23	Birch[a]	139	75.2
24	Yellow poplar[a]	139	75.2
25	Elm, American	138	74.7
26	Gum, tupelo	138	74.7
27	Gum, black	133	72.0
28	Pecan	132	71.4
29	Cottonwood, eastern	130	70.4
30	Beech, American	124	67.1
31	Sycamore	116	62.9
32	Oak, white	113	61.1
33	Oak, red	113	61.1
34	Willow, black	95	51.4
35	Balsa[a]	...	....

[a] Woods commonly used in aircraft.

our neglected woods offer superior properties for specific uses, see Tables 1 to 7, inclusive.

The comparative properties of black willow were examined because this species has long been used for wooden limbs "because of its great strength and light weight." Unfortunately, with the exception of shear, all of the values examined fell very low on the comparative strength-weight ratio table.

There is a close parallel between the lack of statistical verification of the reasons given for the use of black willow and selection of woods for many other high-strength uses, including aircraft. The so-called standard aircraft woods are commonly used with the firm belief that they are the best for the purpose, or frequently (as in the case of spruce) the best for all purposes.

Yellow poplar is sometimes substituted for spruce without engineering changes but the unit compressive strength parallel to the grain-specific gravity ratio of yellow poplar is only 87 as compared with 125 for spruce, Table 4.

Comparisons of other aircraft woods in this highly important strength feature reveal the fact that Douglas fir ranks fifth, spruce tenth, African mahogany fifteenth, American mahogany thirty-first, and yellow poplar thirty-second. The little used western red cedar, redwood, and Norway pine top the list.

It is interesting to note that not a single commonly used aircraft wood is found in the first thirteen woods rated according to their shear-specific gravity ratios, Table 6. The rarely used soft maple has double the rating obtained by American mahogany or Douglas fir. The commonly used shear blocks (glue blocks) of spruce, yellow poplar, and Douglas fir have only 55, 54, and 47 per cent, respectively, of the efficiency of hickory.

The comparison of elastic modulus-specific gravity ratios reveals the one outstanding property of many so-called aircraft woods. Douglas fir leads in this respect with spruce ranking

TABLE 4 WOODS RATED ACCORDING TO COMPRESSIVE STRENGTH - SPECIFIC GRAVITY RATIO

(Compression parallel to grain)

No.	Species	Maximum crushing strength-specific gravity ratio, 10^2	Percentage of no. 1
1	Red cedar, western	147	100
2	Redwood	146	99.3
3	Pine, Norway	143	97.3
4	Cedar, Port Orford	139	94.6
5	Douglas fir[a]	137	93.2
6	Walnut, black[a]	135	91.8
7	Hemlock, western	134	91.2
8	Hickory, shagbark	128	87.1
9	Pine, western white	126	85.7
10	Spruce[a]	125	85.0
11	Pine, ponderosa	125	85.0
12	Persimmon	124	84.2
13	Magnolia	122	83.0
14	Pine, sugar	121	82.3
15	Mahogany, African[a]	121	82.3
16	Maple, soft	119	81.0
17	Pecan	114	77.6
18	Gum, tupelo	114	77.6
19	Ash, white	113	76.9
20	Basswood	112	76.2
21	Maple, hard[a]	112	76.2
22	Cottonwood, eastern	109	74.1
23	Birch[a]	107	72.8
24	Sweetgum[a]	102	69.4
25	Fir, noble[a]	102	69.4
26	Sycamore	101	68.7
27	Elm, American	100	68.0
28	Gum, black	100	68.0
29	Balsa[a]	100	68.0
30	Beech, American	98	66.7
31	Mahogany, American[a]	95	64.6
32	Yellow poplar[a]	87	59.2
33	Oak, red	87	59.2
34	Oak, white	87	59.2
35	Willow, black	83	56.5

[a] Woods commonly used in aircraft.

TABLE 5 WOODS RATED ACCORDING TO FIBER STRESS IN COMPRESSION - SPECIFIC GRAVITY RATIO

(Compression parallel to grain)

No.	Species	Fiber stress-specific gravity ratio, 10^2	Percentage of no. 1
1	Red cedar, western	118	100
2	Cedar, Port Orford	110	93.3
3	Douglas fir[a]	110	93.3
4	Redwood	109	92.5
5	Hemlock, western[a]	107	90.8
6	Pine, Norwary	104	88.2
7	Walnut, black[a]	102	86.6
8	Fir, noble[a]	102	86.6
9	Pine, western white	101	85.7
10	Spruce[a]	100	84.9
11	Pine, sugar	97	83.1
12	Pine, ponderosa	97	83.1
13	Mahogany, American[a]	95	80.6
14	Magnolia	95	80.6
15	Mahogany, African[a]	91	77.2
16	Yellow poplar[a]	87	73.9
17	Persimmon	86	73.0
18	Maple, soft	85	72.1
19	Ash white	84	71.3
20	Basswood	84	71.3
21	Maple, hard[a]	84	71.3
22	Hickory, shagbark	83	70.4
23	Cottonwood, eastern	82	69.6
24	Gum, tupelo	82	69.6
25	Birch[a]	80	67.9
26	Sweetgum[a]	76	64.5
27	Pecan	75	63.6
28	Beech, American	74	62.8
29	Elm, American	73	61.9
30	Oak, white	71	60.3
31	Oak, red	71	60.3
32	Sycamore	68	57.7
33	Gum, black	63	53.4
34	Willow, black	49	41.6
35	Balsa[a]	...	...

[a] Woods commonly used in aircraft.

TABLE 6 WOODS RATED ACCORDING TO SHEAR STRENGTH-SPECIFIC GRAVITY RATIO

No.	Species	Shear strength-specific gravity ratio, 10^1	Percentage of no. 1
1	Hickory, shagbark	338	100
2	Maple, soft	336	99.4
3	Gum, tupelo	306	90.5
4	Pecan	301	89.1
5	Persimmon	292	86.4
6	Pine, ponderosa	276	81.7
7	Elm, American	274	81.1
8	Sycamore	262	77.5
9	Magnolia	260	76.9
10	Willow, black	256	75.7
11	Gum, black	243	71.9
12	Pine, Norway	240	71.0
13	Balsa[a]	227	67.2
14	Maple, hard[a]	225	66.6
15	Redwood	224	66.3
16	Ash, white	220	65.1
17	Sweetgum[a]	208	61.5
18	Mahogany, African[a]	208	61.5
19	Beech, American	197	58.3
20	Pine, sugar	192	56.8
21	Birch[a]	191	56.5
22	Oak, red	188	55.6
23	Oak, white	188	55.6
24	Spruce[a]	187	55.3
25	Red cedar, western	185	54.7
26	Hemlock, western[a]	184	54.4
27	Yellow poplar[a]	181	53.6
28	Basswood	180	53.3
29	Walnut, black[a]	177	52.3
30	Cedar, Port Orford	173	51.2
31	Fir, noble[a]	173	51.2
32	Mahogany, American[a]	169	50.0
33	Douglas fir[a]	158	46.7
34	Cottonwood, eastern	153	45.3
35	Pine, western white	152	44.9

[a] Woods commonly used in aircraft.

TABLE 7 WOODS RATED ACCORDING TO COMPRESSION PERPENDICULAR TO GRAIN - SPECIFIC GRAVITY RATIO

No.	Species	Compression perpendicular-specific gravity ratio, 10^1	Percentage of no. 1
1	Ash, white	362	100
2	Mahogany, American[a]	346	95.6
3	Maple, hard[a]	324	89.5
4	Persimmon[a]	319	88.1
5	Walnut, black[a]	309	85.4
6	Pecan	308	85.1
7	Hickory, shagbark	302	83.4
8	Mahogany, African[a]	298	82.3
9	Oak, red	272	75.1
10	Oak, white	272	75.1
11	Douglas fir[a]	255	70.4
12	Beech, American	253	69.9
13	Red cedar, western	235	64.9
14	Cedar, Port Orford	234	64.6
15	Birch[a]	234	64.6
16	Maple, soft	226	62.4
17	Sweetgum[a]	225	62.1
18	Hemlock, western[a]	216	59.7
19	Fir, noble[a]	215	59.4
20	Pine, sugar[a]	212	58.6
21	Spruce[a]	210	58.0
22	Gum, black	209	57.7
23	Gum, tupelo	206	56.9
24	Redwood	205	56.6
25	Yellow poplar[a]	188	51.9
26	Pine, western white	179	49.4
27	Pine, ponderosa	176	48.6
28	Pine, Norway	163	45.0
29	Sycamore	158	43.6
30	Elm, American	155	42.8
31	Cottonwood, eastern	151	41.7
32	Basswood	150	41.4
33	Magnolia	142	39.2
34	Willow, black	117	32.3
35	Balsa[a]	70	19.3

[a] Woods commonly used in aircraft.

fifth, yellow poplar twelfth, and western hemlock (a spruce substitute) thirteenth. It should also be noted, however, that the mahoganies and sweetgum are far from outstanding in this property, Table 1.

Many woods excel in one or more properties and are relatively deficient in others. Comparisons of the ratings of a few properties of specific woods to determine which is the best universal aircraft wood only obscures the fact that some woods have one or two exceptional properties which make them preferable for particular uses.

Based upon their strength-weight ratios, Douglas fir exceeds all other common woods in stiffness, white ash is best for compression perpendicular to the grain, Table 7. For shear loads, shagbark hickory and soft maple rank well ahead of all others. In compressive strength parallel to the grain (as a column) western red cedar, redwood, and Norway pine are the leaders. Shagbark hickory has by far the highest cross-breaking strength as measured by modulus of rupture, Table 2.

It is realized, of course, that for every special use the limiting wood property must also be considered as, for example, the low shear value of western red cedar may prevent its use as a column compression member in some cases. There is ample evidence to indicate that careful analysis of available data will reveal a number of woods that can be used in certain applications with a definite improvement in strength-weight efficiency.

STRUCTURAL-DESIGN CONSIDERATIONS

To compete with metals in aircraft use, wood structures must be designed for greatest possible efficiency, utilizing all inherent properties of wood to best advantage. Accurate designing, however, necessitates reasonably complete knowledge of all structural properties of the material. It is unfortunate that we not only lack a great deal of basic structural data but are also laboring under the handicaps of misinformation disseminated by (1) partially informed proponents of the use of wood, and (2) proponents of metal, relatively uninformed about wood. Only through the facts as disclosed by efficiently executed designs can wood hope to achieve a permanent use in aircraft in face of present and impending future competition.

The frequent admonishment that we should take advantage of the orthotropy of wood is misleading. It is true that we must use the orthotropy of wood in the best possible manner but only to overcome the fact that wood is weaker in one direction, not because its orthotropy is an advantage. Certainly an isotropic material is to be preferred to an orthotropic material of the same weight that possesses equal strength in only one direction. Endeavoring to make wood as nearly isotropic as possible often defeats our purpose, however, as few uses require high strength in all directions and the maximum obtainable in any one direction is reduced by this attempt. Only through careful analysis of stresses, with less emphasis on the stability of the unattached plywood sheet, can the disadvantage of orthotropy be nullified.

One of the most common misconceptions in comparisons of wood with metal is that of relative stiffness values. It is frequently stated and numerically proved that weight for weight wood is far stiffer than steel or aluminum. The usual modulus of elasticity-depth cubed formula ($Et^3/12$) is used to illustrate this fact.

In fact, however, metal panels of the type used on aircraft are always reinforced by stiffening members, increasing greatly and efficiently the thickness of the panel. Such comparisons must be made on the basis of the complete panel structure that it is possible to make from the material, not on the basis of the skin alone.

Frequent statements are made relative to the strength-weight advantage of wood as compared with metal; usually the tensile strength is used. Usually the compressive strength is the limiting factor in aircraft design, however, and in this property wood has a lower strength-weight factor than do most metals.

With the two foregoing limitations in mind it is well to examine those physical properties of wood which may prove superior in aircraft structures:

Simplicity of fabrication seems to be an assured advantage of wood. Its greater unit stiffness permits great reduction in the amount of supporting material required. Elimination of a large percentage of the material conventionally used for spars, stringers, and ribs, can be effected; local thickenings in the skins, or occasional webs, would be used where the skin alone is unable to carry transverse plate loads or where skin loads must be collected to feed into attachments (e.g., wing-to-fuselage connections). Elimination of supporting components reduces the amount of assembly work required. It is possible that appreciable weight savings can be made in this manner, due in part to greater efficiency in the use of material.

Wood is considerably superior to other aircraft-construction materials in aerodynamic efficiency. The much greater skin stiffness between the supporting members can be used to eliminate the diaphragm deflection ("oil-canning") that reduces the efficiency of the metal-airplane surfaces. The smoother surfaces obtainable with wood will appreciably reduce drag also.

In order to use wood laminates effectively, full advantage must be taken of the wide range of properties available in various species and constructions. A plywood skin that is too thin will "oil-can" in large unsupported areas as severely as will a metal covering. For the same weight, however, lower-density woods will give a greater depth of section and a correspondingly greater skin stiffness.

Probably the most promising type of wood construction is in the field of lightweight core plywood. In such constructions, the faces are composed of two or more ordinary plies of wood; the core is of lightweight material such as solid low-density wood, spaced parallel strips, latticelike arrangement of strips, corrugated plywood or veneer, or low-density plastic material. Balsa has frequently been used as a core for this type construction; it is effective but difficult to use on curved surfaces.

One of the most serious drawbacks to the complicated development of efficient wood aircraft structural design is paucity of accurately determined physical constants.

The following data should be made available for all wood species:

1 Young's moduli (in three directions).
2 Shear moduli (in three directions).
3 Poisson's ratios (six required).
4 Ultimate strength and yield strengths at various angles to the grain for: (*a*) compression loading, (*b*) tension loading, (*c*) shear loading.
5 Typical stress-strain curves for items 4 (*a*), (*b*), and (*c*).

At present almost complete reliance is placed upon the United States Forest Products Laboratory for basic data determination. A number of other laboratories are conducting excellent studies of particular related problems. If all the needed data are to be collected in the near future it must be done through the co-ordinated efforts of the many interested organizations. To the author's knowledge such a well co-ordinated program for the study of basic wood properties does not exist in this country today.

CONCLUSIONS

Continued use of wood in aircraft structures and for some other highly stressed applications, in the face of intense competition from other materials, is dependent in part upon the amount of detailed engineering data that is made available in the near future and upon the extent to which the wood materials and wood products are improved in uniformity and quality.

Following is an enumeration of the measures proposed to stimulate wood use in aircraft:

(*Continued on page 660*)

WOMEN *Who* WORK *for* VICTORY

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WOMEN were first hired for direct production work in the fabrication and assembly of aircraft by the Consolidated Vultee Aircraft Corporation only a little over two years ago. At that time the employment of women was somewhat of an experiment, since this type of work had long been considered as coming within the province of men exclusively. That is not true today.

At the San Diego Division of the author's company, women now constitute more than 45 per cent of the total working force. Current inductions of new employees are being made in the ratio of 65 women to 35 men. These figures prove that aircraft production by women is no longer an experiment but a fact. The volume of plane deliveries before and after the appearance of women in direct production prove their presence has not been deleterious.

During the past two years, women have demonstrated on the job that they are capable of performing most fabrication and assembly work. At the same time, management has learned by experience that, if women are to be used effectively, certain adjustments must be made in supervisory methods, in tool designs, and in work routines. These changes must be made to accommodate the special mental, emotional, and physical attributes of women.

In making these revisions, the procedure was similar to that which would confront a company's engineers, if the product manufactured were converted from a material whose working characteristics had been established to one whose characteristics were relatively unknown.

The aircraft industry had been engineered, tooled, and supervised in terms of the job experiences, job habits, and job aptitudes of men. When women workers entered aircraft production, it was found that a new labor material had to be dealt with and one different in many respects from that to which the industry was accustomed.

In any discussion of women's success or failure in direct industrial production, it is only fair to admit that, while industry faces a problem in modifying its procedures in terms of women workers, the women, on their part, are confronted with equally great adjustments in adapting themselves to industry.

Any program for bringing women into factories and plants will be far more effective if it is conducted on a give-and-take basis, due consideration being given to the fundamental fact that women, by and large, are entering a situation for which neither their past experience nor their past training has fitted them.

In the present discussion, based on operations made at the Vultee Field Division, and at the San Diego Division of Consolidated Vultee, there is no intention to imply that this experience exactly duplicates that of any other industrial organization which has instituted a similar program. The variables in company operations, in company locations, and in company policies require that any particular program be adjusted to fit the specific conditions involved.

PHYSICAL DIFFERENCES BETWEEN WOMEN AND MEN WORKERS

Fundamental to any consideration of how and where women may be used in aircraft production work is the obvious fact that men and women are not alike. Aircraft jobs were originally set up for men. Our first task, therefore, in bringing women into the aircraft industry was to examine the nature of the differences between men and women. With these established, we could then modify our procedures accordingly. A brief summary of the physical points at variance between men and women as they apply to their working capabilities is given as follows:

In bodily structure the average man is larger than the average woman. But women are not just small men. They are also formed and proportioned differently.

Women's hands differ from men's hands in that, proportionately, their thumbs tend to be shorter and their index fingers longer. These differences in hands contribute to women's deftness in the rapid handling of small parts and small assemblies.

Women also have proportionately shorter arms and legs and longer trunks than men. This necessitates a change in the measurements of work benches originally set up for men. The average elbow height of the women in our plants was found to be 39.9 in. Thus, her bench should be about 37 in. high. Her reach is also about 10 per cent less than that of the average man. Consequently, the width of the benches originally designed for men should be reduced by that amount. In redesigning other work layouts for women in fabrication departments and on assembly lines, these differences in elbow height and reach should be borne in mind.

It has been mentioned that women are smaller than men. But the comparative differences in strength are greater than the mere differences in size. The average woman's body is only 35 per cent muscle in comparison to the average man's 41 per cent. Women's muscles are also proportionately longer and thinner, and their muscle fibers less viscous.

Of a woman's weight, only 54 per cent is strength. Of a man's weight, 87 per cent is strength. This means a woman is not only smaller, but proportionately she has less sheer muscular strength per pound. For this reason the average woman's hand squeeze exerts only a 48-lb pressure, while the average man squeezes 81 lb.

For all of these basically physical reasons, it is easy to see why women on production jobs need more frequent rest pauses than men. The average woman worker, it has been found, will have a greater output at the end of the day if she has been given an opportunity to rest. By making a series of small payments on her fatigue debt, she is enabled not only to increase the volume of her output, but to maintain its quality as well.

In considering the comparative muscular control exercised by men and women an interesting fact develops. In light rhythmical movements women are faster and more accurate than men. But if a decision is to be made in the course of the operation, women immediately slow down. A marked delay occurs in what is known as the "decision time."

Production engineers have taken this reaction delay into account when arranging work schedules for women. Whenever possible, an operation should be set up in detail so that the need for making decisions does not arise. By making the work fully routine, the natural deftness of women can be utilized to the greatest advantage.

The differences between men and women in the joint alignments of the knee and elbow account for those peculiarities of feminine throwing and walking which men have always regarded with indulgent amusement. That a woman finds it difficult to throw a ball, or to keep her balance on a precarious

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footing, is the logical outcome of the angle at which her arm bones are joined at the elbow, and her leg bones are joined at the knee.

A man's thigh bones are relatively straight while a woman's thigh bones incline inward toward the knee. It is this inward inclination of the thigh bones that make it more difficult for her to maintain her balance. Insurance statistics confirm this tendency to stumble or fall down. This tendency requires special care in placing women on jobs that necessitate the climbing of ladders or moving around on high platforms.

The same inward inclination of the upper arm bone on a woman accounts for her difficulty in throwing a ball and in the handling of those tools, such as screwdrivers, which require a rotary arm motion.

So far this discussion has been limited to a consideration of physical differences between men and women as it affects their work routines. But equally important to those agencies charged with the responsibility of production in all its varied aspects are the emotional or temperamental differences.

DIFFERENCES IN TEMPERAMENT

Emotionally, women are more volatile than men. They are also more sensitive to environmental influences. Weather conditions, the attitudes of associates, factory surroundings; all those things which men more or less take in stride exert a definite influence on women's productivity.

The greater emotional volatility of women is particularly noticeable in their reaction to supervision. Men on the job will exchange a large share of good-natured kidding and enjoy it. This will occur between foreman and workers with no ill feeling on either side.

But women do not like this rough approach and it should be avoided or there will be hurt feelings, perhaps tears, and certainly an impairment of working efficiency.

Women are particularly appreciative of praise. They work better under commendation than criticism. They also resent correction in front of fellow workers and should be given instruction privately whenever possible.

Another difference in the approach of women toward group tasks is that they dislike open competition. They do not respond well to contests whether at play or at work. Personal or group competition is apt to set up a pressure on a woman employee, which will retard her work rather than accelerate it.

This dislike of open competition is especially to be remembered in establishing training courses and induction procedures. Inexperienced women should be grouped with other inexperienced women in training, or in being started on a job, so that they receive reassurance from the fact that others are having the same difficulty in mastering the new work.

This lesser selfassertiveness of the woman is an advantage on many jobs. If something goes wrong, she does not hesitate to call in the foreman rather than try to correct the difficulty herself. Also she is more willing to admit a mistake and ask for assistance than a man. This makes for better control of the quality of the work handled by women, and for the immediate correction of any fault in the job setup.

Having examined the chief differences between men and women on production jobs, let us consider some of the means by which management has contrived to revise or adapt its supervisory procedures and job setups to accommodate these changes.

JOB SIMPLIFICATION BECOMES A NECESSITY

The necessity of hiring women for direct production jobs has reacted advantageously upon the job-simplification program. It was full use of job simplification by the author's company which made it possible to become the first military-aircraft producer to employ women in the shop. The trend in this direction may be illustrated as follows:

Not so long ago, it was customary for a foreman merely to hand a shop order to a workman and let the latter carry on from that point. It was up to the workman to make his own tooling setup and plan whatever operations might be necessary to produce the part, or assembly of parts, required. In doing so, he gained from blueprints a rough conception of what the finished items were expected to be. Since they would have to fit together with other parts or assemblies, he checked on the latter to find out more about what he had to do. In due time, if the parts he made fitted into place without too much cutting and trimming, the workman became known as a good craftsman. Under the impetus of war production, systems to supplant this reliance on individual craftsmanship began to appear. Volume output makes job simplification mandatory.

One of the first steps in sheet-metal fabrication, for instance, was to provide a template for each part to be made. Such templates or patterns eliminated all the necessity of checking back on finished airplanes. It even made blueprint reading unnecessary.

From a hiring standpoint, it became possible to employ less experienced applicants. Hence a far greater labor supply was tapped.

The next move was to supplant the reference templates with tool setups for each operation. Such items as profile and saw blocks, drill jigs, dies, flat templates for power brakes, and form templates for circle shears were supplied. Used in combination with the machine tools for which they were intended, they made each fabricating operation a comparatively simple routine.

At repetitive routine operations that are not too strenuous, women excel. For this reason, we have been able to hire them for most of the jobs in the sheet-metal department.

Our entire tooling program has been based upon this progressive simplification of production methods. Of course, any simplification of work benefits either male or female employees. But the program of new tooling has been given special emphasis because the majority of new employees are women workers. It was necessary for us to develop jobs and working conditions suitable for semiskilled or unskilled workers, and make the operations simple, if we were to use women workers efficiently.

As an example, we formerly assembled a complicated structure in a single assembly jig and then drilled and riveted the assembly. This required the worker to assume many awkward positions and to work around and behind numerous locators holding the individual parts.

In contrast, now most of the operations are carried out in a series of subassemblies worked on separately. Further simplification is attained by precoordinating rivet holes and then combining these minor subassemblies in a simple type of mating fixture. Even the job of drilling the precoordinated holes is being accomplished by means of mechanical dies which require the operator to do nothing more than place the parts within the die while the press does the work.

This saves the laborious hand-drilling of each hole and then the rehandling of the parts as each drilled hole is individually burred. This type of simplification is applicable to assemblies which are more or less third-dimensional.

In our anlysis of an airplane, however, we find that a majority of all work can be broken down into what we term "two-dimensional assembly." Sections included in this group would be spars, bulkheads, floor panels, and comparatively flat-surface panels. These are fast blocks of work which can be completed easily. We are endeavoring to establish these panel assemblies in vertical-type assembly fixtures, mounted in most cases on trunnion stands which permit swinging the panels at various angles convenient to the workers.

We are also striving to keep the end silhouette of all panel-type tools within an established boundary. The purpose of this definite boundary has been to facilitate the use of semi-automatic drilling, riveting, and routing machines.

These three operations constitute practically all of the work that is done in the fabrication of panel units, and we are obtaining equipment for each of these operations. Such equipment is either track- or floor-mounted, thus avoiding the necessity for manual handling. In many cases, as an expedient, we have resorted to track mounting and counterbalancing of drilling and squeeze-riveting equipment for hand use.

Recognizing that all flat-panel-assembly work allows the workman to stand out in the open instead of in cramped positions within assembly jigs and housed-in subassemblies, new splices or new assembly breakdowns are being developed in the airplane which permit a greater number of flat-panel assemblies. Also, these flat-panel-assembly structures are at least 6 in. lower for women than the normal position required when used by male employes.

IMPROVEMENT IN TOOLS AND EQUIPMENT IS ONE FORM OF JOB SIMPLIFICATION

Another interesting instance of job simplification that resulted from making an adjustment to compensate for a woman's lack of strength may be cited. Parts being milled in the machine shop required clamping in position on the moving table that feeds them through the cutter. The vise formerly employed for this purpose was actuated by a crank. It served well, so far as was known, and its quick action saved an appreciable amount of time over previous designs.

Then a woman was assigned to a mill so equipped. Her supervisor, in the course of his duties, noticed that she kept a mallet handy while operating the machine. Alert to the advantage of being curious about all details, he paused to observe her. When the cutting operation was completed, the woman picked up the mallet and rapped the crank handle a sharp blow in order to loosen it. The operations of releasing the milled part and replacing it with a new one were accomplished in the usual manner. But, to apply final tension on the vise, she again resorted to use of the mallet, driving the crank handle through its last fraction of a turn.

It wasn't necessary for the supervisor to ask the reason. The muscular effort necessary to finish tightening the vise was too much for the woman's strength and resistance to fatigue. Using the mallet was easier.

Out of that incident a new, automatic mill vise came into existence. It is air-operated, a flip of the valve sufficing to release or tighten the jaws. And it is faster compared with the former type.

Instances, in which this effort to fit the job to women has accomplished not only the end in view but has shown the way to faster, better, and more economical methods, could be multiplied.

The advantage of suspending even comparatively lightweight equipment from counterbalances has been widely developed in most departments. Stands and platforms have been supplied, or jigs lowered, to bring all working positions within women's height limits and eliminate stretching or climbing.

Where the weight of objects to be handled exceeds the 25-lb limit set by law, equipment is devised such as that used at one of the final assembly-line stations. It enables a woman operator to hoist twice the limit weight by simply pressing a foot pedal.

All work on the powered fuselage-conveyer assembly line at the Vultee Field Division is done by women. On that line, and on the engine balcony, air-driven wrenches and screw drivers, lightweight electric drills, and rivet squeezers are the rule. Special supports are used to hold jigs and assemblies, the weight of which would cut down the efficiency of women workers if they had to hold them as men do.

Women as a group are not especially mechanically minded. At least they are not mechanic conscious and have not learned many things which seem to come as second nature to men. For that reason it has been found necessary to conduct special classes for foremen and assistant foremen in the instruction and training of women.

The special foremen's classes are conducted by representatives from the various service departments and cover such subjects as labor relations; training for workers; supervision of women; employment, transfers, and terminations; medical services; safety.

The training division also conducts a series of classes for women designed to give them training in the various trades and occupations involved in aircraft construction.

Because family obligations so definitely regulate the attendance and efficiency of female employees, and more indirectly the record of the husband who may also be working at the same plant, the company has established services to assist in solving problems inherent in this situation.

It is frequently necessary for management to transfer women employees from one department to another as the flow of work increases or decreases in the department. These transfers are approved by transfer interviewers, whose chief duty it is to determine the physical fitness of the worker for the new job. If the worker is physically capable of handling the job, the transfer is effected; if not the worker is retained in the original department or a transfer made to a department having work suited to her physical limitations.

This acts as a safeguard to the woman worker's health and saves much time for management. When a woman worker develops physical disorders or limitations on the job, she must be examined by the medical department, her limitations ascertained, and a suitable work adjustment made. Sometimes, when no satisfactory adjustment can be offered, it is necessary to advise an employee to terminate her employment with the company, as her physical condition is such that her health would be permanently impaired if she should continue on the job. This procedure creates much better feeling than to have a foreman tell a worker, "You can do the job or quit."

COUNSELORS FOR WOMEN

In this discussion of the modifications of company procedure which have been made in order to accommodate women in direct production work, one new department we found it necessary to establish should be mentioned, namely, the Women's Counseling Service.

Apparently, feeling they had proved their point when they had demonstrated their ability to do the jobs, some of the women began to take advantage of the special rest-room privilege accorded them. Up to that time only foremen had been given the right to correct deficiencies in the women's conduct, and they had had very little to correct. But the rest-room situation presented a poser. Obviously, foremen could not invade the women's rest rooms. The situation was admittedly delicate. A woman needed only imply that her absence from the job was necessary, and her foreman could do nothing about it.

To meet this problem, the first "matron" was hired. With her access to the rest rooms, she was not slow in breaking up the smoking and conversation parties.

From that simple disciplinary beginning, the counseling service grew into one of the most important factors in the adjustment of women to production work. This occurred because counseling was not limited merely to disciplinary action.

Early in our experience, we discovered that in hiring a woman we frequently assumed a partial responsibility for her entire family. The reason for this is readily understandable. Traditionally, the men in this country were expected to go outside the home to work in the professions, the stores, and the factories. Women, on the other hand, were expected to remain in their homes and devote their energies to the creation and maintenance of a happy family life. Both of these spheres of effort were full-time jobs.

Now what happened when, in the war emergency, women went outside their homes to replace men on a production job? Did they turn over their household jobs to someone else, thus

leaving them free, as the men had been, to give their entire time to the new work? In many cases, no. They kept their regular household responsibilities, and they added another full-time job to the one they were already doing.

The counselor's primary obligation is to aid and assist in discovering and seeking corrective action for any situation that is interfering with the effectiveness of women employees, whether that situation arises from conditions in the plant, in the community, or in the home.

The counselor is expected to be available at all times to receive specific reports from general foremen, or their assistants, on cases or conditions upon which they wish her help. This may be one of many things; for example, a foreman may call to ask her help with a girl with a bad case of "B.O." It is an easy matter for a woman to talk to another about such things, but for a man it is very difficult. Then again it may be in regard to her clothing; her slacks may be too tight or she may have on a tight-fitting sweater. In either event, it can stop production and often causes considerable comment among the men employees. We encourage women employees to dress modestly and in such a manner as not to attract attention.

The counselors in San Diego are members of the Safety Committee and are called upon many times to advise the girls as to the proper way to wear hair protection, the proper type of shoes, etc., but the actual enforcement of the safety rules rests with the foreman of each department.

The counselor knows the women employees in her territory. It is her duty to win their respect, their liking, and their confidence. If that is done, women will bring to her those personal problems which worry or harass them.

A counselor is assigned to a specific shop area. She covers her section several times during the day, stopping with a word of greeting or welcome to new employees, smiling and speaking to all who might happen to glance up. But she is not expected to carry on a long conversation with an employee.

Counselors contact new employees within three days after induction. They learn as many first names as possible and are careful to use them. As time goes on a skillful counselor will learn a great deal about family affairs and children of the women workers.

Through proper company channels counselors report conditions or cases for corrective action, if the matter is of such nature as to permit its solution within the plant. For example, a woman may be working at a bench where her stool may be either too high or too low. She may feel somewhat reluctant to speak to her foreman about it, but she will be entirely free to speak about it to a counselor. In such a case, the counselor calls the foreman's attention to the situation in a diplomatic manner. Usually he has not noticed it and in most cases will correct the condition immediately.

The counselor always goes to the foreman of a department and gives him an opportunity to correct something in his department. She never takes anything over his head.

As the connecting link between the woman needing help in solving a home, family, or community problem and the community agency equipped best to help her, the counselor's services are invaluable. She knows the heads of the various welfare, health, and religious agencies in the community, as well as the housing agent, and school facilities.

A counselor is available at all times to receive calls from the Industrial Relations Department in connection with emergency calls in regard to death, serious illness, accidents, etc.

In connection with the responsibilities outlined, there are certain routine duties which the factory manager and his general foremen often wish the counselors to perform for them.

Such routine activities include supervision of women's rest rooms to discourage undue loitering and to report persistent offenders, checking absenteeism among women employees, and such other regular tasks of appropriate character as the factory manager may request them to perform.

The work of the counselors has been credited with the solution of many of the humanitarian problems involved in the company program for hiring women employees. Beginning in a small way as a simple disciplinarian solution to a specific rest-room loitering situation, their service has been expanded to include consultations with both women and management on every phase of women employment.

CONCLUSIONS

In concluding these comments on the place of women in war industry, the author wishes to express his sincere praise of their efforts. The call to arms in this country that came with the Japanese attack on Pearl Harbor found women ready to respond in their traditional spheres of activities as they have always responded to every national emergency.

They contributed by Red Cross work, by carrying the main burden of registering and issuing ration books, by serving as air-raid wardens and in the air-raid-warning system, by taking nursing-aid courses, by saving fats in their kitchens, and in the many other ways with which we are all familiar.

They also served by continuing their most important work as women, namely, that of maintaining their homes, that of caring for their husbands, and that of guarding the health and well being of their children. These were tasks for which they were well qualified by their aptitudes and past training.

As the war progressed, however, and as more and more men were called into the armed services, there came the demand for women to enter war industries. There they faced tasks for which they were not immediately qualified by aptitudes or past training.

At their work with the author's company, women have demonstrated their value in aircraft production. From the president of the company down to the last assistant foreman, the organization is doing everything possible to help them become efficient as well as enthusiastic workers for victory.

When women arrived on the production and assembly lines they brought with them a whole host of problems. These problems are being solved at a rapid rate. In the meantime, with some inconveniences and with a lot of hard work by women employees and management both, the increasing number of planes that we must have to win the war are rolling off assembly lines that are more and more being manned by women.

Problems Affecting the Use of Wood in Aircraft

(Continued from page 656)

1 Wood Quality Improvement:

(*a*) Segregation of wood (including veneers) into more restricted specific-gravity groups.

(*b*) Reduction of veneer and plywood tolerances.

(*c*) Complete control of wood moisture content through all stages of manufacture.

2 Basic-Data Analysis:

(*a*) Study the available strength data of all wood species to determine accurately the various species offering advantages where particular stresses are dominant.

(*b*) Utilize these woods to obtain greater strength-weight efficiency.

3 Structural-Design-Data Accumulations:

(*a*) Conduct the necessary tests to determine the basic structural-design data that have not yet been determined for our native wood species. These include Young's moduli (3), shear moduli (3), Poisson's ratios (6), ultimate and yield strengths for various angles to the grain, and typical stress-strain curves.

(*b*) Advance the wood-aircraft designs as rapidly as possible, digressing as far from the "conventional" as is necessary to use wood in its most efficient manner.

TRAINING EMPLOYEES
for the War and After

By R. O. JOHNSON

SUPERVISOR OF TRAINING, INTERNATIONAL HARVESTER COMPANY, CHICAGO, ILL.

THE impact of the war on industrial training in the author's company can be best understood by reviewing briefly the development of training programs by the company during the last two decades. Because training normally must be predicated on future needs, it is appropriate to make some reference to the problems incidental to the return of our men from the military forces and the reconversion to regular manufacture following the war. This paper therefore will cover:

1 The development of company training programs prior to the present war.
2 Effect of the war on training.
3 Training for needs beyond the war emergency.

A foreword on general principles will indicate the company's concept of training for works employees. It has long been recognized that the training of personnel must be subject to modification from time to time to be most effective in meeting prevailing conditions. In some 25 years of formalized industrial training, we have not found an inflexible program which can serve under the various operating conditions, from the extremes of periods of curtailment with their need for limited numbers of versatile employees, to periods of rapid expansion with accompanying small labor supply as at present. It has been our purpose in so far as possible to anticipate these changing conditions and to shape our training work accordingly.

PRELIMINARY TRAINING FOR ASSIGNMENT

For many years it has been a company ideal that every employee be prepared in advance for his particular assignment. The more difficult the job the more essential is the preliminary training. Admittedly, in many instances it is possible to give such training through personal coaching and without extensive planning and scheduling, but we have found the more successful procedure is to train personnel according to predetermined courses and schedules. The advantages in time saved, errors eliminated, and satisfactory adjustment to the job will be obvious.

Since training has to do with the progress and productivity of employees and is affected by changing conditions, the last word on the subject cannot be told. Training will, under any circumstances, constitute an interesting challenge to industrial executives because it is positive, it is constructive, and it is building for the future.

TRAINING AS A BASIC FUNCTION OF SUPERVISION

The preparation and proper induction of new or transferred employees is recognized as a primary function of foremanship. Although this is hardly debatable, its importance is often overlooked. A few questions will help clarify the place of training as a basic function of every supervisor: How is safety accomplished? Through orders or mandate or through good instruction? Are good workmanship and quality product obtained by insisting on them or by teaching the employee how to perform his job? Is sustained, efficient production brought about simply by requesting it? Preliminary training for the new employee, as well as training for every new assignment are readily indicated.

Training is a means whereby safety, quality, quantity, favorable costs, and good labor relations are achieved. It is a regular part of our management function and not a device to employ on special occasions. It is therefore either done well or poorly. Properly recognized and consciously practiced it sets the stage for the fulfillment of most of the supervisor's duties. With good training, the supervisor's task is simplified and the company's objectives more satisfactorily attained. Without it, misunderstanding, confusion, and inefficiency are likely to result. Equally important, the absence of training can leave an organization understaffed in supervisory, technical, and other positions requiring special skill.

A recent statement by the president of our company, Mr. Fowler McCormick, exemplifies the attitude of our management on training:

"Some of the objectives which we must strive to attain are better efficiency, improved understanding, and increased employee satisfaction. The essence of training is to b ing about (1) a full knowledge of the job to be done and the ability to do it; (2) an understanding of the company and its operations; and (3) an awareness on the part of every employee of his importance in our organization and of the fact that he is an integral part of it."

DEVELOPMENT OF TRAINING PROGRAMS PRIOR TO THE WAR

Our training experience provides the background for present activities. Systematic training has long been practiced in many phases of our operations. This has been accomplished through carefully planned and executed programs designed to increase the skill and knowledge of employees on certain subjects, to give supervisors and other employees helpful information to carry out their respective duties, and to prepare individuals for upgrading.

Specifically, it has been achieved at the supervisory level through the holding of discussion conferences and lecture meetings, letters, printed matter, and other media. The first formal program for foremen training was instituted in 1920 and was known as the "foremen's development course." This program included a schedule of lectures accompanied by printed material on matters pertinent to the foremen's job, and covered all manufacturing operations in the Chicago area. Indicative of the importance placed on training at that time were the establishment of a central library, and the introduction of plant visitation programs as adjuncts to the foremen's development course. Some years later discussion conference courses were introduced at all United States and Canadian works of the company, and in recent years they have followed regular schedules of determinate conferences for the continuing instruction of company supervisors.

Training has been achieved at the presupervisory level for about 15 years through preparing carefully selected young men for foremanship and other responsible positions; and for well over a quarter of a century through giving qualified boys systematic training in the skilled trades. In a less formal but equally definite way, employee training in the semiskilled and

Contributed by the Committee on Education and Training for the Industries and presented at the Spring Meeting, Davenport, Iowa, April 26–28, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

unskilled categories has been carried out during this same period.

A few years ago, training was organized on an even more definite and regular basis and became a major activity of our manufacturing operations. New and higher standards were established, and all United States and Canadian works of the company were brought within the purview of the program to assure maximum benefits to all concerned. A director of training was appointed for each works and a central training department created at the general office to administer the program. We believe that, over the years, training in the Company has had a healthy and sound growth.

It is a matter of great pride that vacancies are usually filled by promotion from within the organization. Officers, managers, foremen, and others are almost invariably selected from employees within the ranks. The relationship between upgrading and training is recognized, and the programs already mentioned give effect to this plan of promotion from within the ranks, based on preliminary training. These activities include the following: (1) foremen conferences; (2) organization meetings; (3) progressive students course; (4) preparatory course for foremanship; (5) mergency preparatory course for foremanship; (6) supervisory training course for women; (7) cooperative engineering course; (8) apprenticeship courses; (9) job-training courses.

EFFECT OF WAR ON TRAINING

No branch of our economy has been left untouched by the war, and the manufacturing industries, carrying out the war-production program, have undergone numerous and far-reaching changes. New lines of product accompanied by heavy losses of experienced employees to the military services have created an unprecedented demand for training of inexperienced employees in all occupations.

In our company, we have greatly curtailed the output of tractors, motor trucks, and farm implements, for which have been substituted a large variety of war materials. We have to date lost to the armed forces more than 8000 experienced men from the United States manufacturing organization alone. Clearly, job training has had to be greatly accelerated, with old employees and new employees alike receiving instruction to enable them to contribute most to the war-production schedule.

Today, our efforts are devoted principally to three categories of training rather than the more comprehensive program normally followed. These are (1) employee or job training; (2) short-term courses for the development of new supervisors; and (3) foremen conferences. Both men and women are included in these activities. Student training and our standard four-year preparatory course for foremanship have by and large been temporarily suspended, because we cannot permit men to remain in training the full time required by these courses, and also because of our increasing inability to retain young men enrolled as trainees, owing to selective-service requirements. Our four-year apprenticeship courses are similarly affected, especially as concerns boys in the first and second years of training.

Job Training. Job or learner programs include both on-the-job and vestibule-school activities. On-the-job instruction is sometimes preferred because it brings the learner in direct contact with the actual operating conditions which he must encounter in his regular work, and also because productive output is likely to be greater under such conditions. Vestibule schools are used when large numbers have to be trained in a given skill at one time. In other instances, the vestibule-school plan is employed for basic training, thus preserving the full productive capacity of the operating departments for the more experienced employees.

In all this effort emphasis is placed upon making the job being taught as simple as possible so that the new or upgraded employee will be most willing and best able to undertake the work. The principal objectives are (1) to bring the learner up to normal output in the shortest possible time, (2) to prevent damage to material and equipment to the utmost, (3) to minimize labor turnover, and (4) to secure uniform results under all conditions, i.e., different shifts, departments, etc.

On two factors rests largely the success of job training, i.e., (1) proper selection and training of the instructor, and (2) determination of just what training is to be given and in what order. These essential features cannot be overemphasized, particularly under existing conditions when time is so vital and manpower so scarce. The individuals selected for instructors should be carefully coached in (1) the art of teaching—they should know how to impart their knowledge and have the ability to motivate the learner so the learner will be anxious to learn; (2) what to teach—be specific as to methods and manual movements, quality, quantity, etc., and (3) follow-up of the new employee to assure mutually satisfactory adjustment to the job. The "training-within-industry job-instructor training" program can very well form an important part of this instruction. Some 2000 company foremen and job instructors have taken the J.I.T. course.

Training courses cover a variety of occupations in machine shop, assembly, welding, inspection, foundry, forge shop, and other operations and include both men and women. The nature and extent of such job training are governed by the character and complexity of the job in question. In Davenport, Iowa, is located the Bettendorf Welder Training School, where we successfully trained, by means of a four-week course, several hundred inexperienced employees and certified them as armor-plate welders.

Training of Women. Most of our courses for new women employees provide for 24 hours of classroom work during the first two weeks of employment accompanied by intensive job instruction under competent instructors. In the classroom, related technical instruction is given in blueprint reading, shop mathematics, safety requirements, importance of quality, shop terms and use of gages, micrometers, and hand tools. Visual aids are used to a limited extent in this work and have proved helpful in bringing a variety of shop conditions into the classroom. This effort has resulted in minimizing labor turnover and greatly facilitating the employees' induction and has aided in the development of safety attitudes and safe work practices.

In view of the fact that most women applicants are wholly inexperienced in shopwork, we are now establishing vestibule schools at all plants for the preliminary training of new women employees. Here, simple standard machine tools, assembly benches, and other equipment are installed and the beginner receives her initial shop experience, saving the full equipment capacity of the operating departments for productive purposes. The advanced and more specialized training is given in the operating departments.

Training of Prospective Supervisors. Urgent and unforeseen demands for new supervisors, men and women, necessitated the temporary suspension of the regular four-year preparatory course for foremanship and in its place was instituted the emergency preparatory course for foremanship. The new plan provides for 6 months of intensive training, divided into 10 weeks in the department or field for which the student is being trained, and 16 weeks in the methods and rates, industrial relations, production control, mechanical engineering, and accounting departments. Discussion classes are conducted at least once a week on pertinent company policies, the employee-foreman relationship, union contract, and other subjects. The course is covered by a written plan setting forth purpose, selection procedure, eligibility requirements, pay scale, etc. The works training department is required to enroll in the foremen conference program employees who complete this training immediately upon assignment to supervisory positions.

A new activity which came into being as a result of the war is a plan for giving promising women employees intensive training to qualify them for the position of "supervisor of women,"

which is a staff function and includes liaison work between the women employees and the company, assisting in the employment of new women employees, and other duties. Through this course, we have already developed a number of such women and placed them at many different locations. The training was given at our West Pullman Works in Chicago, and at the St. Paul, Minn., works because of the large numbers of women employees at those points.

Foremen Training. Another essential activity in the company's war-training plan is foremen training. The foremen conferences already described are serving as a most vital part of the three-part program. Many perplexing problems now confront the foremen, and their role in the war effort requires that every possible assistance be given them. Their normal routine is complicated by difficulties in getting materials and equipment, the manpower shortage, the need for greater emphasis on espionage and sabotage, and all at a time when new products requiring the most accurate quality must be produced. Co-operation between the members of a plant organization, and co-ordinated effort, were never more necessary than now.

Realizing that each operation would benefit most through foremen conference schedules on subjects peculiar to their existing urgent needs, we have temporarily discontinued the preparation of printed conference material which heretofore has regularly been distributed by the Chicago office. On special occasions, however, material of general interest is issued to all works for inclusion in conference discussions.

Foremen conferences can and do supply solutions to perplexing problems. They go far toward assuring uniformity of interpretation and unity of action.

Summary. Summing up this discussion of the effect of the war on industrial training, we see the introduction of programs which will quickly convert the available manpower to produce material for warfare. Thus have emerged (1) job training on a larger scale than ever before, (2) short intensive courses for the development of new supervisors, and (3) a new and more pressing need for assisting foremen through foremen conferences, educational classes, and meetings.

Trained labor is rapidly becoming the controlling factor in producing and delivering the goods that our men in uniform must have, and training, consequently, is occupying an increasingly important place in the operation of our war-production plants. "Too little and too late," was partly the result of an insufficient number of available war-production workers. Shortage of trained workers is helping bring about the downfall of the Axis at a time when our manpower is becoming more formidable. Our advantage in this respect will contribute much toward the final victory.

TRAINING FOR NEEDS BEYOND THE WAR

Today's objective is clearly defined and nothing must be allowed to interfere with our war efforts. Since in-service training must be predicated on future needs, some thought should, however, be given to carrying on after the cessation of hostilities. It would probably be fruitless to undertake a study of the shape of things to come, but the re-establishment of our employees who return from the military branches, and the conversion of our manufacturing facilities to peacetime manufacture will entail some important adjustments which can best be accomplished through advance planning. How well we provide for the induction of the men who return from the armed forces will depend to a great extent upon what preparation has been made for retraining, and it shall be our purpose to give the best possible attention to this matter.

Changes, progress, and development are the inevitable order of industry, and the future will probably require an even higher type of leadership than the past. Only through training can such leadership be provided.

The training experience of the past has to a great degree enabled us to meet the manpower problems occasioned by changeover and labor shortage during this first stage of the war. A critical study of our entire organization and the probable future inroads that will be made by selective service is now well under way for the purpose of being ready to make replacements when and as necessary. The training experience thus acquired will provide further guidance for the modified training programs which must accompany the changes from war production to normal operations.

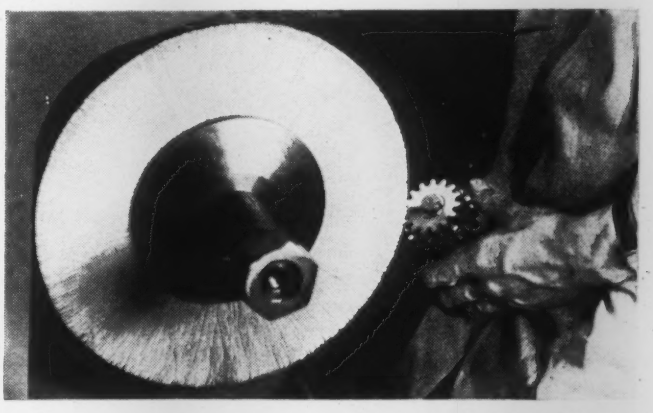
Diesel-Engine Maintenance in the Navy

(Continued from page 632)

There is still in every organization much of the talent that brought the Diesel engine in the United States to its unchallenged peak in quality, output, and performance. Each of these organizations worked out, in its own laboratory and on its own proving ground, its own peculiar problems during the trying and arduous development period. Today the Navy offers to the Diesel industry (in fact to the whole engineering profession) the greatest series of laboratory tests and proving-ground trials ever available to man. The Navy has more Diesel horsepower and more individual power plants operating today under one banner than have ever been operated in history. These plants are operating under the most trying conditions, in every possible type of weather and climate and over unbelievable lengths of time and space.

If the greatest good possible is to be obtained from this world-wide laboratory, it must come in the form of increased reliability; 100 per cent reliability must be our goal. To accomplish this goal the Navy asks the Diesel industry to bring to bear all the talent that put it in the forefront of modern power development; to come into this great laboratory that has the oceans of the world for its test floor, the howling winds of the Arctic and the burning sun of the tropics for its test tubes, and the blood of our own brothers and sons for its catalyst, and develop for us propulsion units that will withstand any test, any trial, and any combination of man, war, or weather. Metallurgists, designers, and production experts will have to work as an integrated team to accomplish this task for we cannot delay production for an instant.

On the day we begin to receive reports from the commanding officers of our ships "Annual routine inspection completed—no replacements required," this miracle we ask you to perform will be an accomplished fact. That the industry can approach this goal we have no doubt. How close can it approach it? That is for the industry itself to answer. There are thousands at sea on ships under the most adverse conditions who are anxiously awaiting such an answer.



Osborn Mfg. Co.

FIBERS OF MEXICAN CACTUS, KNOWN AS "TAMPICO," FORM BRUSHING PORTION OF BRUSHING WHEEL USED EFFECTIVELY TO CLEAN AND DEBURR TEETH OF PRECISION-MADE AIRCRAFT GEAR

Recommended Specification for
PRIME-MOVER SPEED GOVERNING

FOREWORD

THE plan for the formation of a joint A.I.E.E.-A.S.M.E. committee for the purpose of preparing a recommended specification covering the speed regulation of prime movers intended to drive electric generators that may, if desired, be included in prime-mover purchase specifications, was approved by action of the Board of Directors of the A.I.E.E. on Jan. 30, 1941, and of the Council of the A.S.M.E. on June 15, 1941.

The personnel of this joint committee was nominated jointly by the chairman of the A.I.E.E. Committee on Power Generation and that of the A.S.M.E. Standing Committee on Power Test Codes. The joint committee operated under the sponsorship of the Power Division of the A.S.M.E.

The need for a recommended specification arose from recognition that confusion existed in regard to values of desirable, possible, and acceptable performance characteristics for the speed governing of prime movers and in nomenclature employed in connection therewith.

It was recognized that the fundamental studies necessary for the writing of such a specification are identical with those for the preparation of the A.S.M.E. Power Test Code on Speed-, Temperature-, and Pressure-Responsive Governors which has been assigned to the A.S.M.E. Power T st Code Committee No. 20. The need of close collaboration between the standing committees of the two societies was recognized and is the reason for joint activity and the method of selection of the joint committee's personnel.

While the joint committee was appointed for the purpose of preparing a recommended specification covering the speed governing of all types of prime movers intended to drive electric generators, the specification is for the present limited in its scope to steam-turbine generators of not less than 10,000 kw rated capacity.

The recommended specification does not cover emergency governors or other overspeed devices.

The subjoined document contains the recommended specification and also some informative matter and definitions that would not ordinarily be included in a purchase contract or specification.

The technical literature on the subject of speed governing has emphasized certain characteristics as being important in defining speed-governor performance. The committee concurs in those conclusions. It is recognized that this specification does not include all the functional and performance characteristics relating to the speed governing of prime movers that might be specified, but only those which are considered important, capable of measurement, and capable of being supplied by the manufacturers with equipment of standard design. As the understanding of this subject progresses and when better measuring techniques and improvements in design are developed, additional characteristics may then be found important and can then be added.

The Joint A.I.E.E.-A.S.M.E. Committee was appointed in 1941 for the purpose of drafting recommended specifications covering the speed governing of prime movers intended to drive electric generators. Although the Joint Committee has been delegated to draft specifications covering the speed governing of all types of prime movers intended to drive electric generators, it has, for the present, limited its activity to the preparation of a draft covering the speed governing of steam-turbine generators rated at not less than 10,000 kw.

The Joint Committee has intentionally limited the contents of the proposed recommended specification to those functional and performance haracteristics that are generally believed to be the minimum requirements for satisfactory and acceptable speed governing. It is recognized that amplification or modification of the contents of the proposed recommended specification may be desirable in particular cases. It is not intended that the proposed recommended specification preclude such action.

The Joint Committee desires to obtain the comments of the profession at large on this recommended specification for use as a basis for revision in advance of presentation to the A.I.E.E. Board of Directors and to the A.S.M.E. Council for approval and adoption, and as a guide for the amplification of the proposed recommended specification to include other types of prime movers. Critical examination and constructive criticism of this specification is therefore invited. An opportunity for further discussion will be afforded during the A.S.M.E. Annual Meeting, Nov. 29–Dec. 3, 1943.—MAX J. STEINBERG, *Chairman.*

It is recommended that the purchase specification include the following:

(*a*) That the standard equipment of Pars. 24 to 29, inclusive, be supplied by the manufacturer.

(*b*) That the manufacturer shall supply such of the optional equipment of Pars. 30 to 34, inclusive, desired by the purchaser and agreed upon by the manufacturer.

(*c*) The performance specification of Pars. 35 to 47, inclusive, to be guaranteed by the manufacturer.

(*d*) The requirements of Pars. 48 and 49.

The *Personnel of the Joint A.I.E.E.-A.S.M.E. Committee on a Recommended Specification for Prime-Mover Speed Governing* is as follows:

M. J. STEINBERG, *chairman*

Representing A.I.E.E.

S. B. GRISCOM, central-station engineer, Industry Engineering Dept., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

A. P. HAYWARD, investigating engineer, Power Stations Dept., Duquesne Light Co., Pittsburgh, Pa.

J. B. MCCLURE, Central Station Engineering Dept., General Electric Co., Schenectady, N. Y.

F. OPPENHEIMER, system chief operator, Pennsylvania Water and Power Co., Baltimore, Md.

V. M. MARQUIS, Engineering Dept., American Gas and Electric Service Corporation, New York, N. Y.

M. J. STEINBERG, division engineer, System Engineering Dept., Consolidated Edison Company of New York, Inc., New York, N. Y.

Representing A.S.M.E.

C. L. AVERY, engineer, Woodward Governor Co., Rockford, Ill.

H. ESTRADA, superintendent, Economy Division, Philadelphia Electric Co., Philadelphia, Pa.

J. R. HAGEMANN, designing engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

A. F. SCHWENDNER, control engineer, Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.
R. SHEPPARD, head of control section, Turbine Engineering Dept., General Electric Co., Schenectady, N. Y.
C. R. SODERBERG, professor of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass.
R. J. CAUGHEY (*deceased*), Turbine Engineering Dept., General Electric Co., Schenectady, N. Y.

Recommended Specifications for Prime-Mover Speed Governing

SECTION I OBJECT AND SCOPE

(1) The purpose of this specification is to recommend functional and performance characteristics relating to the speed-governing of prime movers intended to drive electric generators that may, if desired, be included in prime-mover purchase specifications.

(2) For the present, this specification is limited in its scope to steam turbines intended to drive electric generators of not less than 10,000 kw rated capacity.

SECTION II TERMS AND DEFINITIONS

Speed Governing System.

(3) The speed-governing system includes the speed governor, the control mechanism, and the governor-controlled valves.

Speed Governor.

(4) The speed governor includes only those elements that are directly responsive to speed and which position or influence the action of other elements of the speed-governing system.

Control Mechanism.

(5) The control mechanism includes all equipment such as relays, servomotors, pressure- or power-amplifying devices, levers and linkages between the speed governor, and the governor-controlled valves.

Governor-Controlled Valves.

(6) The governor-controlled valves include those valves which control the energy input to a prime mover, and which are actuated by the speed governor through the medium of the control mechanism.

Speed Changer.

(7) The speed changer is a device capable of changing the setting of the speed-governing system for the purpose of varying the speed or the power output of the prime mover while in operation.

Load-Limiting Device.

(8) The load-limiting device is a device which acts on the speed-governing system to prevent the governor-controlled valves from opening beyond the position for which the device is set.

Steady-State Over-All Speed Regulation.

(9) Steady-state over-all speed regulation is the change in sustained speed, expressed in per cent of rated speed, when the output is changed from full rated power output to zero power output with identical settings of all parts of the speed-governing system. Thus

$$\text{Per cent} = \frac{\text{Speed at zero output} - \text{Speed at full rated power output}}{\text{Rated speed}} \times 100$$

(10) The steady-state over-all speed regulation may vary with different settings of the speed changer. For the purposes of this specification the percentage regulation derived from the formula of Par. 9 shall be based upon rated speed obtaining with full rated power output.

(11) The effect of speed-changer setting on the steady-state over-all speed regulation is illustrated in Figs. 1 and 2.

Steady-State Incremental Speed Regulation.

(12) The steady-state incremental speed regulation at a given steady-state speed and power output is the rate of change of the steady-state speed with respect to the rate of change of power output as measured from the *given* steady-state speed and power output. It is expressed in per cent of rated speed and is the change in sustained speed expressed in per cent of rated speed, divided by the change in power output, expressed as a fraction of full rated power output for the corresponding change in speed. This gives the slope of the curve between the two speed and power outputs. Thus

$$\text{Per cent} = \frac{[\text{Speed at output } (a) - \text{Speed at output } (b)] \div (\text{Rated speed})}{[\text{Output } (b) - \text{Output } (a)] \div (\text{Full rated power output})} \times 100$$

(13) For the purposes of this specification the several points of power output from which steady-state incremental speed regulation is computed by the formula of Par. 12 shall be based upon rated speed obtaining at each point of departure of power output, with identical settings of all parts of the speed-governing system during any one determination.

(14) Application of the formula of Par. 12 is illustrated in Fig. 3 for one type of valve-gear design.

Speed Regulation (General).

(15) Speed regulation is considered positive when speed increases with decrease in power output.

(16) All definitions concerning regulation are based on zero dead band.

Dead Band.

(17) Dead band is the total magnitude of the sustained speed change expressed in per cent of rated speed within which there is no resulting measurable change in the position of the governor-controlled steam valves. Dead band is a measure of the insensitivity of the speed-governing system.

(18) For a given governor-controlled-valve position there may be both an increase and decrease in speed before there is a change of valve position. In this case the total magnitude of the sustained speed change referred to in Par. 17 is the sum of these speed changes.

Stability.

(19) Stability is the capability of the speed-governing system to position the prime-mover governor-controlled valves without *sustained* oscillations of prime-mover speed or power output with constant connected load, or following a change of power output.

(20) For the purposes of this specification the speed-governing system of the prime mover shall be deemed stable if the *sustained* speed oscillations of the prime mover under constant connected load conditions or following a change of power output are no greater with the speed governor in operation than when it is blocked or inoperative.

Overspeed.

(21) Overspeed is the maximum increase in speed from an initial speed if the generator, while operating at a stated speed and power output, is suddenly and completely disconnected from the load. Overspeed is expressed in per cent of rated speed.

SPECIFICATIONS

Terms and Definitions.

(22) All terms and definitions used in this specification shall be in accordance with the terms and definitions adopted by the Joint A.I.E.E.-A.S.M.E. Committee on a Recommended Specification for Prime-Mover Speed Governing.

Remote-Control Devices.

(23) Except upon agreement to the contrary, the equipment supplied by the manufacturer as specified hereinafter is to be exclusive of control devices at points of remote control including any connecting means between points of remote control and the specified equipment.

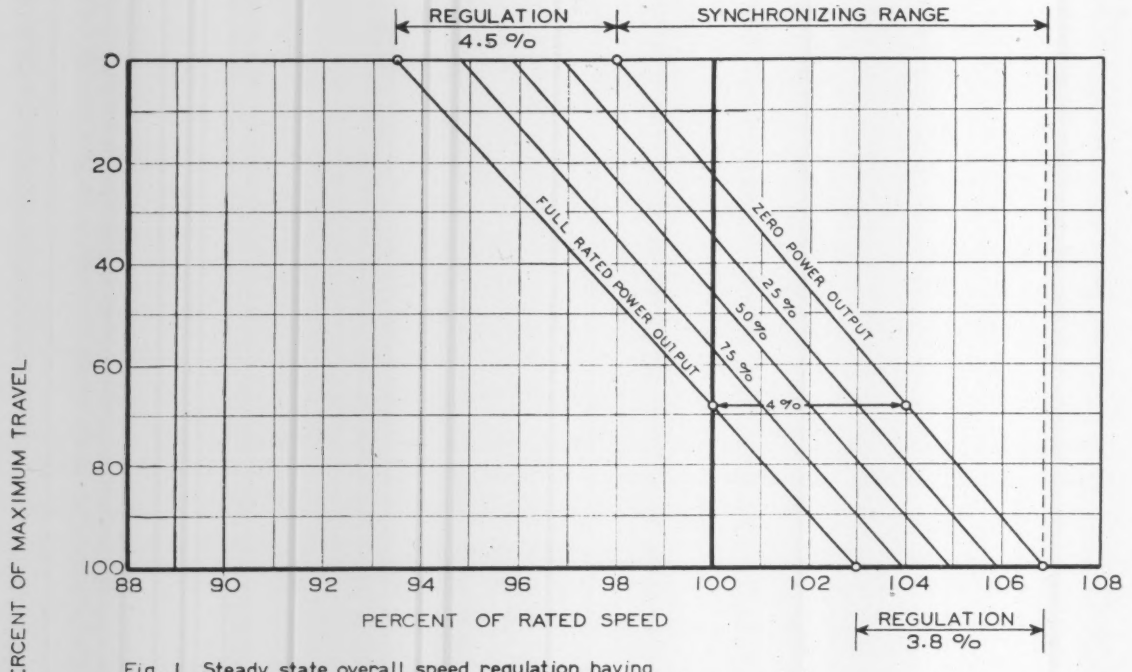


Fig. 1 Steady state overall speed regulation having practically uniform values for different speed changer settings

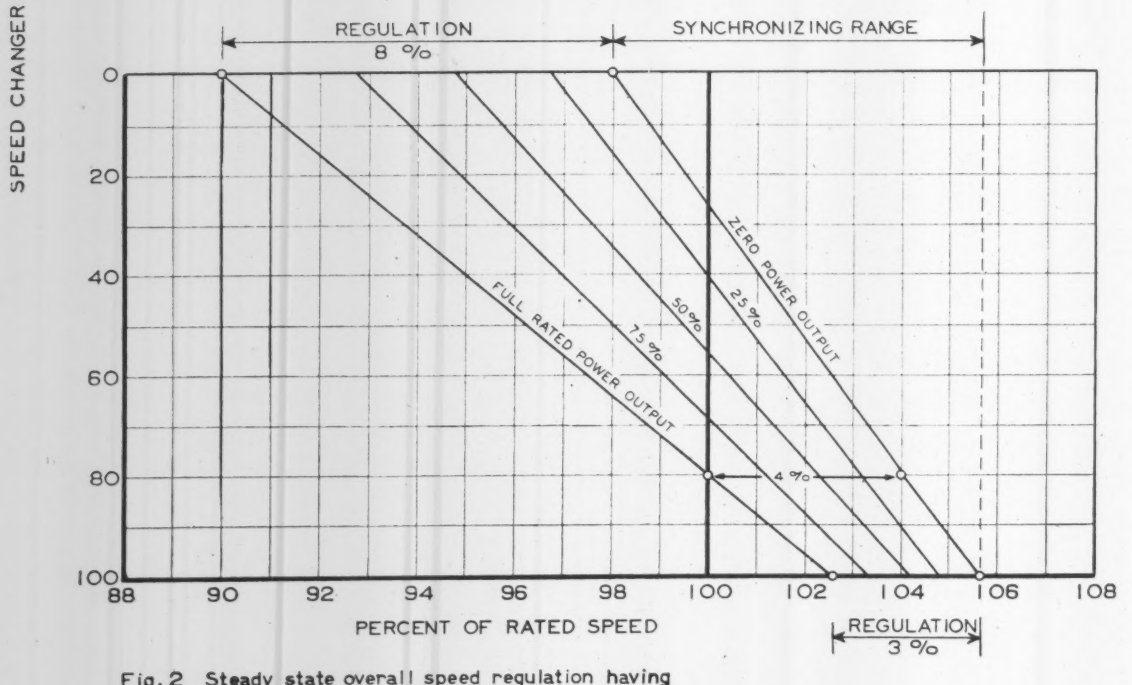


Fig. 2 Steady state overall speed regulation having different values for different speed changer settings

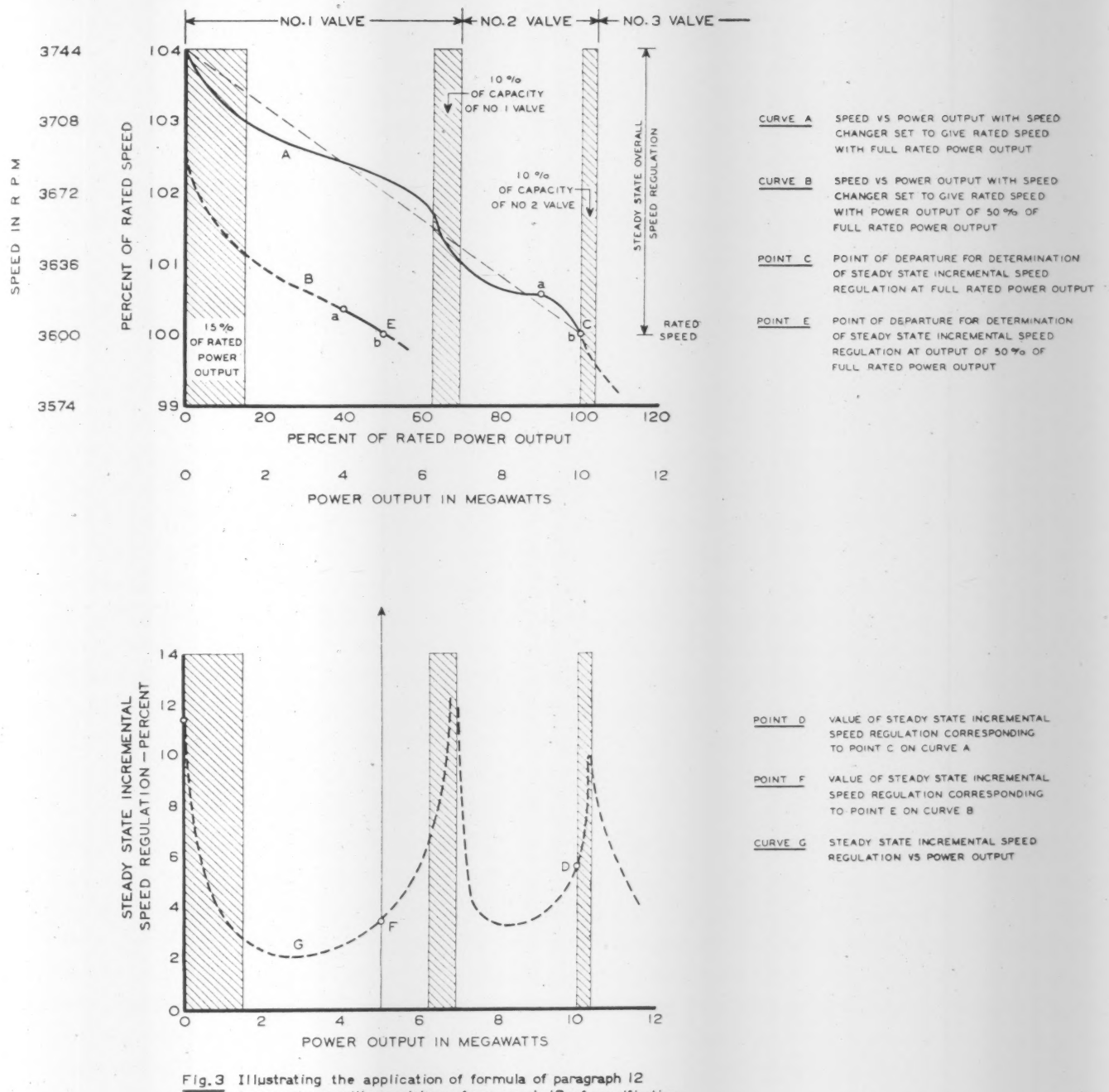

NO. 1 VALVE
NO. 2 VALVE
NO. 3 VALVE
SPEED IN R P M
PERCENT OF RATED SPEED
3744
3708
3672
3636
3600
3574
104
103
102
101
100
99
10 % OF CAPACITY OF NO 1 VALVE
10 % OF CAPACITY OF NO 2 VALVE
STEADY STATE OVERALL SPEED REGULATION
RATED SPEED
15 % OF RATED POWER OUTPUT
A
B
C
D
E
F
G
a
b
0 20 40 60 80 100 120
PERCENT OF RATED POWER OUTPUT
0 2 4 6 8 10 12
POWER OUTPUT IN MEGAWATTS
CURVE A SPEED VS POWER OUTPUT WITH SPEED CHANGER SET TO GIVE RATED SPEED WITH FULL RATED POWER OUTPUT
CURVE B SPEED VS POWER OUTPUT WITH SPEED CHANGER SET TO GIVE RATED SPEED WITH POWER OUTPUT OF 50 % OF FULL RATED POWER OUTPUT
POINT C POINT OF DEPARTURE FOR DETERMINATION OF STEADY STATE INCREMENTAL SPEED REGULATION AT FULL RATED POWER OUTPUT
POINT E POINT OF DEPARTURE FOR DETERMINATION OF STEADY STATE INCREMENTAL SPEED REGULATION AT OUTPUT OF 50 % OF FULL RATED POWER OUTPUT
STEADY STATE INCREMENTAL SPEED REGULATION – PERCENT
0 2 4 6 8 10 12 14
0 2 4 6 8 10 12
POWER OUTPUT IN MEGAWATTS
POINT D VALUE OF STEADY STATE INCREMENTAL SPEED REGULATION CORRESPONDING TO POINT C ON CURVE A
POINT F VALUE OF STEADY STATE INCREMENTAL SPEED REGULATION CORRESPONDING TO POINT E ON CURVE B
CURVE G STEADY STATE INCREMENTAL SPEED REGULATION VS POWER OUTPUT

Fig. 3 Illustrating the application of formula of paragraph 12 in accordance with provisions of paragraph 13 of specification for one type of valve gear design

SECTION III EQUIPMENT SPECIFICATION

STANDARD EQUIPMENT

(24) The manufacturer shall equip the prime-mover generator set with the following standard equipment.

Speed-Governing System.

(25) A speed-governing system capable of controlling and regulating the speed of the prime mover in conformity with the performance characteristics hereinafter specified by Pars. 35 to 47, inclusive.

(26) The speed-governing system specified by Par. 25 above shall be provided with means by which the steady-state overall speed regulation shall be capable of adjustment to values within the limits specified by Par. 39. This adjustment need be possible only when the prime mover is not in operation.

Speed Changer.

(27) A speed changer capable of varying the speed or power output of the prime mover while it is in operation within the limits specified by Pars. 45 and 46. The speed changer shall be suitable for synchronizing the generator for parallel operation with other generators and shall be capable of varying the speed or power output of the prime mover by means of manual adjustment at or near the speed-governing system and also by means of remote control.

Load-Limiting Device.

(28) A load-limiting device capable of manual setting at or near the prime mover, for the purpose of limiting the degree of opening of the governor-controlled valves to any value

within the full range of valve travel, while the prime mover is in operation.

Miscellaneous.

(29) Any instruments, control or safety devices not specified as standard equipment but considered by the manufacturer to be necessary or desirable.

OPTIONAL EQUIPMENT

(30) The following or other optional devices may be specified by the purchaser.

Adjustment of Steady-State Over-All Speed Regulation.

(31) The speed-governing system specified by Par. 25 shall be provided with means by which the steady-state over-all speed regulation shall be capable of adjustment within limits mutually agreed to by the purchaser and the manufacturer, while the prime mover is in operation at any power output within its full rated power capacity.

Remote Indication.

(32) Means for the remote indication of the setting of the load-limiting device specified by Par. 28.

(33) Means for the remote indication of the positions of the governor-controlled valves or of any other element of the speed-governing system to be specified by the purchaser.

Setting of Load-Limiting Device.

(34) Means for setting the load-limiting device by remote control within the limits specified by Par. 28.

SECTION IV PERFORMANCE SPECIFICATIONS

(35) The following performance characteristics and numerical values are recommended to be specified:

Operating Conditions.

(36) The performances hereinafter specified are to apply with the prime-mover throttle valve in a fully open position and with the prime mover operating under the specified conditions as to pressures, temperatures, and steam extractions.

Stability

(37) The speed-governing system specified by Par. 25 shall be capable of controlling the speed of the prime mover with stability at all power outputs between zero and maximum power output, inclusive, with the generator operating isolated or in parallel with other generators.

Steady-State Over-All Speed Regulation.

(38) The steady-state over-all speed regulation shall be approximately 4 per cent when the speed changer specified by Par. 27 is set to give rated speed at rated power output.

(39) The steady-state over-all speed regulation shall be capable of adjustment to values between 3 and 5 per cent, inclusive.

(40) If required by the purchaser, the steady-state over-all speed regulation may be specified at a value less than that recommended by Par. 38 hereof to the extent agreed to be practicable by the manufacturer.

(41) The manufacturer shall furnish with his proposal curves showing the relation between the setting of the speed changer specified by Par. 27 and the speed of the prime mover for power outputs of 0, 25, 50, 75, and 100 per cent of full rated power output.

Steady-State Incremental Speed Regulation.

(42) The steady-state incremental speed regulation at rated speed shall at any power output be not less than one half or more than twice the steady-state over-all speed-regulation value specified by Par. 38, except that

(*a*) for the last 10 per cent of the load change resulting from the opening of any individual governor-controlled valve, the *average* steady-state incremental speed regulation shall not exceed three times the steady-state over-all speed-regulation specified by Par. 38, and

(*b*) for the first 15 per cent of rated power output the steady-state incremental speed-regulation values may be more than twice the steady-state over-all speed-regulation value specified by Par. 38 to facilitate the synchronizing of the prime-mover generator unit for parallel operation and to limit the magnitude of the load fluctuations that may be imposed on the prime mover while operating in this range of power output.

Dead Band.

(43) The dead band at rated speed shall not exceed 0.06 per cent of the rated speed at any power output within the full rated power output.

Overspeed.

(44) With the prime mover operating under specified conditions and the speed changer specified by Par. 27 set to give rated speed with *maximum* power output, upon sudden and complete loss of power output the speed-governing system specified by Par. 25 shall be capable of controlling the overspeed of the prime mover to a value which is less than the specified setting of the emergency governor.

Range of Speed-Changer Control.

(45) With the prime mover operating at *maximum* power output, it shall be possible by means of the speed changer specified by Par. 27 to operate the prime mover at speeds up to 102 per cent of rated speed. With the prime mover operating at zero power output, it shall be possible by the same means to operate the prime mover at speeds down to at least 98 per cent of rated speed.

(46) The generator shall be capable, by means of the speed changer specified by Par. 27, of being synchronized by remote control for parallel operation with other generators operating at any speed between at least 98 and 105 per cent, inclusive, of rated speed.

(47) The speed changer specified by Par. 27 shall be capable of being operated by means of remote control at a speed that will cause full rated power output to be removed from the prime mover in not less than 30 or more than 40 seconds.

SECTION V DESCRIPTIVE LITERATURE

(48) The manufacturer shall furnish with his proposal diagrams or drawings of the speed-governing system and of any other equipment specified to be furnished by the manufacturer, together with a written description clearly explaining the principles of operation.

SECTION VI ACCEPTANCE TESTS

(49) Tests to determine the performances specified herein by the purchaser and guaranteed by the manufacturer shall be governed by the provisions of the latest available A.S.M.E. Power Test Code for Speed-, Temperature-, and Pressure-Responsive Governors with such exceptions as may be mutually agreed to by the purchaser and the manufacturer.

AMERICAN STANDARD SYMBOLS *for* HEAT *and* THERMODYNAMICS

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THE list of thermodynamics letter symbols here discussed is part of a project initiated some years ago by the Sectional Committees on Letter Symbols and Abbreviations for Science and Engineering, Z10, of the American Standards Association, under the sponsorship of the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education, to be carried out under the procedure of the American Standards Association.

As a result of the main project, lists of American standard symbols in a number of fields have been issued. Some recently have been revised and reissued, i.e., "Letter Symbols for Hydraulics," ASA Z10.2–1942; "Letter Symbols for Mechanics of Solid Bodies," ASA Z10.3–1942; "Illuminating Engineering Nomenclature and Photometric Standards," ASA Z7.1–1942. To these has now been added the Thermodynamics Symbols,[1] ASA Z10.4–1943. Other revised lists of previously issued standards, and some new lists, are in progress.

A letter symbol is defined as "a single character, with subscript or superscript if required, used to denote a physical magnitude in mathematical equations and expressions."

IDENTICAL SYMBOLS IN DIFFERENT FIELDS

In all A.S.A. symbols particular efforts shave been made to use the identical symbol for such concepts as are common to several fields. Workers in one field often have become accustomed to symbols of their own, regardless of usages in other fields with respect to the same concepts. But the different subcommittees working on letter symbols have been broad-minded in avoiding such conflicts in the new lists already issued, and this is expected to continue with future lists.

A completely logical list of symbols would have a single symbol for every concept, no matter in what field it might be used, and would have all symbols selected on a sound theoretical basis, regardless of present usages. But in default of an international dictator to enforce such an allegedly logical list it just wouldn't be accepted. However, it is expected that the American Standard lists of letter symbols are going to merit actual use, and hence a realistic compromise between existing usages and idealism has been attempted.

ALTERNATE SYMBOLS

One such compromise has been listing of alternate symbols for some concepts. These are of two sorts. In some cases there are alternates of equal rank, denoted by listing two different symbols opposite a concept, with a comma between. In other cases, a preferred symbol in the list for a given field is duly listed, and an unpreferred alternate given in parentheses or as a footnote.

INTERNATIONAL SYMBOLS STANDARDIZATION

In many cases letter symbols are the initial letters of words or names. The fact that different languages use different names has started the use of completely different letter symbols for the same concept in nations using different languages. For this reason, international standardization of symbols for all fields of science and technology seems impossible at present. However, with people using the English language, the possibilities are much brighter.

At the present time, even though people in the United States, Canada, England, and other parts of the British Empire speak nearly the same language, there is a great diversity in the letter symbols used in textbooks and other scientific publications. This is in spite of the fact that books published in one nation are used freely in another, that colleges exchange students, and that commercial concerns in each country have affiliates overseas. Hence standardization by the two nations in co-operation with one another would be advantageous.

With this in mind the Royal Society of England arranged that the British Standards Institution start collaboration on lists of letter symbols for the English language, with other Empire standards associations, the Canadian Engineering Standards Association, and the American Standards Association. The two latter bodies accepted the proposition.

The author was in England in 1938 as delegate to a meeting at Torquay of the International Electrotechnical Commission, where symbols for electrical quantities were fairly well settled internationally. While in England the author participated in the aforementioned arrangements for symbols for the English language for other fields, and definite progress was made in this direction. However, the impact of war compelled postponement of the project in England. The American and Canadian Standards Associations have continued, with such information about the English point of view that it is hoped that the A.S.A. lists being issued will require but little addition when letter symbols for the English language again come to be considered. Furthermore, the American lists will give standards for our use until this happy time comes and will furnish a definite statement of the American point of view when it does come.

ACCEPTANCE OF STANDARD SYMBOLS

Standardization in general is a modern development. At one time every manufacturer of machinery made his parts to suit himself and used his own system of screw threads, for example. Authors of technical papers have customarily exercised a similar independence in their use of letter symbols. There is no need to go into the advantages arising from the abandonment of such ideas, and the standardization of screw threads, carburetor flanges, taper fits, and thousands of other machine items, as well as letter symbols.

Upon completion of a few more of the A.S.A. lists of symbols which are now under way, it is to be hoped that the editors of all technical-society transactions and proceedings will specify that all authors of papers must use standard A.S.A. symbols. It is expected that publishers of technical books will be able to make a similar requirement. But even when all of this occurs it no doubt still will be desirable that each author of a paper or book include a complete list of the letter symbols that he uses.

[1] "Letter symbols for Heat and Thermodynamics Including Heat Flow," approved by the American Standards Association, June, 1943, and published by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

In some texts written for a particular field an author has chosen symbols most convenient for him at the moment, often without consideration of symbols used in other fields for his concepts. Some such books have become so popular that successive editions have been printed, and other writers have followed the symbols customs of the original author. This causes a clash when an attempt is made to standardize a single symbol for a given concept, regardless of the field in which it is used. Difficulty from such divergent practices is one of the reasons for standardizing symbols, and when such divergent practices do exist, either a number of confusing alternates must be standardized or some authors must give up their past practices for the general good.

A number of cases of this kind have arisen in the arrangement of the symbols for heat and thermodynamics. In some cases, authors have agreed to what has been shown to be fairly general practice, in spite of their own previous divergences. In other cases, two different eminent authors have started with divergent symbols, and followers of both have been reluctant to give up the divergent practices.

The subcommittee has attempted to arrange a set of standard symbols for heat and thermodynamics for chemists, physicists, mechanical engineers, chemical engineers, and the like. In a number of cases in the present list extensive search has been made of current literature in various fields, and a symbol finally selected on the basis of majority use, or probability of acceptance by a majority. The author, as chairman of the subcommittee, has filed a number of exhaustive lists of usages for a number of particular concepts and will be glad to furnish copies to those interested. These lists, and correspondence about them, went back and forth among members of the subcommittee, and a final selection was agreed upon either unanimously or by a very large majority, on the basis of best serving the general good. It is repeated that standardization is needed because of divergencies, so sacrifice by some, of their symbols customs, is necessary for the general good.

HOW SOME DIVERGENCIES WERE TREATED

The selections made for the thermodynamics list in particular cases where divergencies have existed are explained in the following paragraphs. These selections were based on lists of usages by various American, British, and continental authorities, copies of which are available.

Energy in general, or total or molal work, has the symbol E in many texts. In these and in many other cases U is the symbol for internal or intrinsic energy. There also has been some use of E for internal or intrinsic energy. It was decided that a definite distinction between energy in general and internal energy was desirable, and so E was selected for the former and U for the latter.

A matter which caused a large amount of discussion was the selection of symbols for what Dr. G. N. Lewis and his followers have called "free energy," $H - TS$; and for the different thing called the "Gibbs function" or "thermodynamic potential," which Helmholtz called "free energy," which is $U - TS$. In these formulas generally accepted standard symbols are U, internal energy; H, enthalpy; T, absolute temperature; and S, entropy. Discussion arose because Dr. Lewis used F for what he called "free energy," while many continental and British writers used the same symbol F for the different concept which Helmholtz called "free energy." This causes confusion in the parallel use of British or continental texts and some American texts. Dr. Rossini of the Bureau of Standards pointed out that since F had appreciable usage, with two quite different meanings, it had best be abandoned altogether. So selection was made of the symbol A for $U - TS$, following Dr. G. N. Lewis (Helmholtz called this "free energy"). And selection was made of the symbol G for $H - TS$, following a great deal of usage. This selection requires that some American chemists give up using F for $H - TS$, since it also has been used for $U - TS$. Long continued discussion showed that this would make for the general good.

Time and Fahrenheit or Centigrade temperature both have had such extensive use of the symbol t that it seemed necessary to perpetuate this double usage. But there has been a great deal of discussion as to what should be done when both concepts appear in a single text. In such cases there has been some use of t for temperature and θ for time. Some of the early masters of thermodynamics used θ for temperature, so that this symbol has become associated with temperature in the minds of many students of thermodynamics and has so been used in many texts. An appreciable majority of our subcommittee thought that from the points of view of all sorts of people using thermodynamics it was best to continue to associate θ with temperature, and that its use as a symbol for time ought not to be perpetuated. Greek "tau" has had an appreciable use as an alternate for t for time, so the following arrangement was approved by a substantial majority of other scientists and engineers with whom the matter was discussed:

t or τ time
t or θ temperature C or F (θ is also used to denote temperature difference)

This gives ample provision for avoidance of conflict when time and temperature occur in the same text.

Some of the symbols for radiation and humidity were subjects of appreciable discussion. Many sorts of people use symbols in both of these subjects and there have been wide divergences. Much confusion and divergence also has been caused by uses of the same names for different concepts. But the American Standards Association symbols project does not include in its scope names or definitions. So standardization of these has been sidestepped and there has been given only enough of a statement of a concept to distinguish it clearly, but without standardization of any such statement. But even with such sidestepping of names there still were great divergencies in the symbols for a number of the concepts. Complete surveys were made of usages among all the different sorts of people using a given concept, and the final selection was made on the basis of the greatest good.

In the case of symbols for radiation a great deal of discussion resulted in complete agreement with committees of the Illuminating Engineering Society on a joint standard, ASA Z7.1-1942. In the case of symbols for humidity, a great deal of discussion resulted in fairly good agreement with meteorologists, thermodynamicists, and specialists in air conditioning.

The meanings attached to the words "mass" and "weight," and the symbols for them, long have been subjects of discussion. It is well known that classical mechanics often use "mass" as meaning gravitational force divided by gravitational acceleration, and always use "weight" as meaning gravitational force on a body. However, Maxwell in his classical "Theory of Heat" wrote, "In all other cases, the word "weight" must be understood to mean a quantity of the thing as determined by the process of weighing against standard weights." Nowadays, a similar understanding is popular, and when a chemist or thermodynamicist or groceryman uses the word "weight," it has to them the significance of "quantity of matter," in spite of the other long-established significance of "gravitational force." So the same significance exists when precise-thinking engineers find the weight of a body by balancing it against standard weights on an equal-arm balance or groceryman's scales. They see no connection with gravitational force, since this "weight" is the same at any latitude or elevation although the gravitational force varies a great deal. So our symbols list must face the fact that two different significances really are in precise use, regardless of arrogation by each side that they are the ones that are "right." We can't settle which is right but we can insist on precise thinking by both sides.

RATIONAL WAR FINANCE[1]

Review of "A Treatise on War Inflation"

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A Treatise on War Inflation"[2] is not, as its title may suggest, a scholarly tome of erudite lucubrations. Nor is it a flashy and popular discussion of current trends. It is a calm and matter-of-fact treatment, largely in nontechnical language, of basic economic considerations underlying the financial policies of governments in time of war. Several chapters are devoted also to a discussion and criticism of measures adopted or proposed in the United States up to October, 1942. A careful reading of "A Treatise on War Inflation" should give the reader a firm economic basis for understanding and criticizing intelligently the steps that are likely to be taken in financing a major war.

IMPACT OF WAR ON ECONOMIC SYSTEM

The general thesis of the author can best be understood by glancing briefly at a simplified picture of the impact of war on the economic system. In peacetime the amounts of various goods produced and the allocation of resources to produce these goods are determined ultimately by the decisions of individuals as to how to dispose of their money incomes. No authoritarian measures are required to effect this result; the operation of the price system brings it about by causing the transfer of resources from one commodity to another in response to changes in their relative prices.

When a country becomes involved in a war, consumers are dethroned as final arbiters of the production of goods and the allocation of resources. The government decides that the economic system must turn out a quantity of war goods sufficient to meet the emergency. If all resources are fully employed at the outbreak of war—an assumption we shall make for the present—there is no choice but to withdraw factors of production from other uses. A part of these needed factors can come from the production and maintenance of capital equipment.

In this case, some of the burden of the war may be avoided for a few years, since the reduction in goods available for consumption occurs, not in the present, but at that future time when the unbuilt or deteriorated capacity would otherwise have been in full operation. In a major war, however, the greater part of the resources will have to be drawn from the production of goods for consumption. The consequent reduction in goods available for consumers is the real, as distinguished from financial, burden of the war. It must be borne in the present and can in no way be shifted to future generations, no matter what methods are used to finance the war. Different methods of financing do, however, alter both the distribution of this burden among income classes in the present and the relative positions of these classes in the postwar world.

As an aid in classifying and evaluating different ways of raising money to pay for a war, the author defines a norm or ideal, which he calls "rational war finance." This ideal is realized if the government—and in a democratic country this means the people through their representatives—faces the issue squarely and comes to a definite decision, in advance, as to how the burden of the war shall be distributed among various groups in the population. In essence, this means that the aggregate of disposable consumer income must be cut down sufficiently to be equal to the total value of goods available for civilians, these goods being valued at prewar prices. If this is not done and consumers spend their excess incomes, then prices must rise. The part of the burden that was not imposed by a reduction in income is thus imposed by a reduction in the power of incomes to buy goods. However, the distribution of the burden resulting from this rise in prices is unplanned and unpredictable and hence not consistent with rational war finance.

It must not be inferred from the preceding discussion that rational war finance requires a freezing of the prices of all commodities. On the contrary, prices and production can be allowed to vary without restriction, except in the case of a few scarce necessities. Once the power of consumers to govern production and allocation has been cut down in accordance with the reduction in available resources, consumers can then be allowed to use their power in the same way they normally do. The result is that the relative amounts of the various goods produced are more closely adjusted to the needs and wants of consumers than would be possible through rationing and price control. The extensive system of price ceilings now being used in the United States is largely the result of having allowed an inflationary process to get under way. The same cannot be said, however, of all the controls now in operation. Even completely rational war finance would not eliminate the necessity for direct allocation of strategic war materials or for some rationing. The government could not afford to compete even with the reduced incomes of consumers for the supply of, say, aluminum. It is easy to see, however, that rational war finance eases the task of enforcement of these controls and lessens the danger of leakage through black markets.

FINANCING THROUGH TAXATION AND COMPULSORY SAVINGS

A war can be financed rationally through the use of taxation, bolstered by compulsory saving if the situation requires. It is interesting to note that rational war finance excludes any heavy reliance on voluntary saving, since such saving comes out of redundant incomes, which could give rise to inflation if individuals chose to spend them. Conformity to the ideal of rational war finance implies extensive use of progressive income taxation, i.e., a tax system in which the rates rise more rapidly than the income base to which they apply. The reason for this is that redundant disposable money incomes are, probably, more than proportionately higher in the upper income brackets. Rationing and other restrictions on consumption help to bring this situation about.

With regard to specific rates for taxing incomes, the norm of rational war finance affords no accurate way of determining whether one set of rates is preferable to another when both sets yield the required total revenue. The crux of the difficulty is that, while redundant disposable income in the aggregate can be unambiguously defined with reference to the value of goods available, there is no way of determining the exact amounts of

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "A Treatise on War Inflation," by William Fellner, University of California Press, 1942, 180 pages.

redundant income in the hands of income groups and, *a fortiori*, in the hands of individuals. It is not possible to choose any system of rates that would reduce incomes by the required amount, since this might do grave injustice to some groups. Hence we can see how a government, with sincere intentions of financing rationally, would, nevertheless, choose to leave a small inflationary cushion of redundant income as a protection to individuals against the inaccuracy of the instrument of taxation.

However, all governments fall short of the norm of rationality by a far greater amount than can be justified on this ground. A more basic reason is that the lack of any objective or scientific tax formula throws the matter open to sharp political pressures. Each income group stands to gain if it can put up such stiff resistance to an increase in its rates that less aggressive groups must bear a larger share of the burden. The net result of this tendency is a strong pressure against any increase in rates, and all rates remain too low to eliminate redundant income. Inflation, apparently, is not greatly feared, possibly because of ignorance, or because of a belief that a certain present loss in the form of higher taxes is more painful than a probable future loss of uncertain size resulting from inflation.

POLITICAL RESISTANCE TO HIGH INCOME TAXES

The political resistance to high income taxes causes greater reliance on another type of tax which is easier to collect but tends to exact a greater percentage of income from lower-income receivers. These consumption taxes (sales taxes and excise taxes on specific commodities) are less desirable than income taxes on grounds of equity and because they do not strike hardest where redundant income is greatest. However, since they operate by raising prices rather than by reducing money income, the public shows less resistance to them.

To round out the case for rational war finance, brief attention will now be given to a few specific arguments against expansionary methods. Under a system of rational war finance, an individual with a given income, say $5000, would bear his share of the real burden of the war—that is, the reduction in consumers' goods—by giving up through taxation a part of his income with which he could have bought consumers' goods. Under inflationary war finance, an individual with the same income would bear his burden by paying taxes, by paying higher prices, and by buying government bonds. These three methods are similar in reducing his capacity to buy goods. The chief advantage of distribution under the first method is that it is planned and predictable. The distribution under the second system is at the mercy of the inflationary process. If prices rose rapidly then great injustice could be done to persons with low fixed incomes. This tendency is, however, partially thwarted by rationing and price control.

Rational war finance would aim at paying for the war during the war. Inflationary methods rely heavily on the sale of bonds to individuals to ease the pressure of redundant incomes. As a consequence, numerous individuals come out of the war with claims against the government for yearly interest and future repayment. This means that each holder of a bond has a claim against all contemporary taxpayers for the payment of interest annually. Expansionary war finance thus alters the distribution of income in future years. Whether the outcome is a more or less equitable distribution need not concern us here. A more important point is the claim that the higher level of taxes needed to meet the income payments might take such a chunk out of the return on investments as to reduce the willingness of individuals to lend money. Such a result is possible in the case of risky loans, but there is no evidence to show that it is quantitatively important in the operation of the economic system.

The most serious danger of inflation is that the mounting prices of consumers' goods may enable producers to attract resources from war production by offering very high prices. Strong direct controls, priorities, wage ceilings, and other measures, are imposed to prevent this tendency, which, strangely enough, would be in peacetime the normal operation of economic forces. However successful these controls are, inflation must be charged with the cost of enforcement and the diversion of sorely needed manpower.

STIMULUS OF INFLATION

So far, we have presented the case for rational war finance, showing, as its chief drawback, the political difficulties of agreeing on tax rates. What follows will be a different line of argument, favoring inflationary methods.

Careful calculation and orderly distribution of the war burden can best be achieved when, as we have assumed, all available resources are fully employed at the beginning of the war. Actually, this is impossible, since the mere outbreak of war is likely to increase the number of persons willing to work. Furthermore, most economic systems are chronically in a state of greater or less underemployment of resources, as was the United States in the thirties. Professor Fellner recognized this and would allow an increase in the supply of money at the same rate at which output was increasing.

The difficulty of making such accurate calculations and acting on them quickly enough is obvious. A far more important objection is this. War expansion is, in many respects, similar to the boom or prosperity phase of the business cycle. In 1937, the sharpest collapse of a boom in our history took place, well before full employment was reached. This sharp downturn coincided with an approximate balancing of the budget and a cessation of the inflationary pressure of previous deficits. Complete proof is lacking, but there is good reason to believe that the withdrawal of the stimulus of the deficit was one of the principal causes. This strongly suggests that a policy of permitting only slight increases in the supply of money and holding prices constant might be dangerous. The expansion in production might be painfully slow or, far worse, the economic engine might stall, sputter, and begin to roll back. To guard against such eventualities it would have been far better to employ the proved stimulus of inflation. On these grounds, the most desirable system of financing the war would be the use of liberal increases in the supply of money to spur the economic system to the fullest employment of resources in the shortest time.

In other ways, also, the employment of rational financial methods might act as a barrier to the greatest possible utilization of factors of production. Monetary incentives to increased effort would be almost entirely eliminated by the severe reduction in incomes necessary to avoid inflation. The familiar "time and a half for overtime" would hold out little inducement to workers, since taxes would have to be higher as a result of the overtime pay. The reason for this is that increased rates of pay for additional work tend to be inflationary, because money income is increased by a higher percentage than the output of goods. Finally, the opportunity to buy war bonds is likely to be a much greater stimulus to increased effort than high rates of taxation.

SUMMARY

In summary, one system of finance would make use of the stimulus of inflation to draw forth the greatest possible production and then rely on direct controls to choke off the more unfavorable effects of that inflation. Rational war finance would carefully avoid using the power of inflation in return for not having to deal with its undesirable aftermath. Rational war finance would clearly be preferable if it were certain to produce the maximum output. In lieu of that assurance, it is probably better to fix our goal as the utmost use of resources, use the method that will bring us to that goal, and rely on our ability to ward off the undesirable consequences.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Future Diesel Road Locomotives

COMMENT BY A. H. CANDEE[1]

It would appear that in this paper[2] on weight saving, the author has predicated his analysis on the wrong basis. In Table 1 locomotive *A* is apparently a three-cab locomotive, each cab being mounted on two 6-wheel swivel trucks. The writer does not believe that any motive-power officer would consider this type of locomotive to be anything but a temporary expedient, which remark also applies to contemporary four-cab freight units. It is sometimes disconcerting to see a beautiful streamlined train approach and pass and then awaken to the fact that it was only an attenuated locomotive after all. The postwar locomotive will undoubtedly be of single-cab construction with a locomotive-type wheel arrangement, which in itself will result in very marked weight reduction over the present temporary designs.

COMMENT BY W. L. DOYLE[3]

Any analysis leading up to choice of one scheme of locomotive construction in preference to another in an assembly of the type described by the author should be strongly influenced by experience, and should include careful consideration of such factors as initial investment, operation, inspection and maintenance work and costs, and the important factor of reliability over a reasonably long useful life prior to the time when excessive maintenance suggests scrapping. Satisfactory and reliable performances are invariably accompanied by favorable operation, inspection and maintenance costs, and these considerations definitely stem from use of properly conservative engineering design and ratings as related to the application.

As pointed out the use of smaller-bore, faster-running engines do offer attractive advantages over the larger-bore, slower-speed engines, because of material savings possible in the way of reduced initial cost, weight, and bulk. Increased engine speeds also permit use of faster lighter generators which, in turn, effects a combined weight saving of real moment. Decrease in weight, if it is accompanied by a construction which may be operated with a definite over-all economy and without loss in desirable performance characteristics, is of course desirable. However, there is a definite minimum locomotive weight requirement for proper starting drawbar pull, and to reduce weight below this minimum is of questionable value, since the addition of ballast which must also be carried around and for which the running gear must be designed will then be disadvantageous. It should be pointed out that reduction of weight of mechanism does not necessarily point to a corresponding proportionate decrease, or in fact, any saving in cost, An airplane engine, while having a very low weight per horsepower, is much higher both in first cost and maintenance than any of the Diesel engines now used in locomotive service.

Under the heading of operating costs, naturally, one of the important considerations is fuel. The larger-bore Diesels in general are able to burn the cheaper, heavier grades of fuels. On the other hand, this feature is not applicable to all of the smaller high-speed Diesels. This is a significant point and one that has been greatly stressed in the development of our "Caterpillar" engines. As a result, today this make of engine is no more sensitive in its fuel requirements than any of the larger-bore, slower-speed Diesels being used in locomotive service. In fact, many of our engines are successfully operating in oil-field localities using various types of crude oils.

Having in mind the several types of Diesel-generator units currently used in locomotive applications, one conclusion which might be drawn from this paper is that the author suggests using a fairly large number of conventional 6- to 12-cylinder fast-running smaller-bore engines for the purpose of providing a total of something less than 6000-hp capacity in the prime-mover equipment for the proposed locomotive. This introduces a question as to the total power capacity obtainable from the practicable number of individual units of this nature which could be physically accommodated in each tractor of the locomotive assembly. Experience seems to indicate that two Diesel-generator units per tractor is the most favorable arrangement. However, some locomotives have been built with as many as four prime movers. The augmented number of currently available smaller-bore engines of conventional construction and individual ratings that would have to be applied on this basis would fall far short of the power capacity per tractor as required for the locomotive under discussion.

The writer inferred from illustrations accompanying the paper that the author proposed the use of two 24-cylinder Diesel-generator units per tractor. If this is correct, it would necessitate at least twice as many cylinders per engine as have been used in locomotive service to date, and thereby would depart from what may be termed current locomotive Diesel-engine developments. In the writer's opinion an important measure of the approach of a given design toward the ultimate development is indicated by the trend toward simplification of construction. This naturally raises the question as to how far we should go along the line of increased cylinders per engine. Use of such a large number of cylinders definitely complicates rather than simplifies the assembly. From the operating point of view, the augmented number of duplicate parts per engine involved in a special arrangement of this type would be expected to result in less favorable costs due to out-of-service time, and other costs including those for inspection and maintenance.

It would be of interest to hear comments on these points from officials responsible for Diesel-locomotive operations. While the writer is in accord with the use of smaller-cylinder-bore, faster-running, higher-output Diesel engines for locomotive work, generally, in line with current conventional developments, it would seem that any marked increase in the number of cylinders per engine over current practice would introduce definite disadvantages militating against the scheme.

COMMENT BY W. S. H. HAMILTON[4]

While this paper is very interesting and shows a considerable amount of study, it is believed that a number of major factors bearing on such a study have been overlooked.

[1] Transportation Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Mem. A.S.M.E.

[2] "Future Possibilities of Diesel Road Locomotives," by P. B. Jackson, MECHANICAL ENGINEERING, May, 1943, pp. 335–338 and 359.

[3] Research Engineer, Caterpillar Tractor Company, Peoria, Ill. Mem. A.S.M.E.

[4] Equipment Electrical Engineer, New York Central System, 466 Lexington Avenue, New York, N. Y.

The design of any road locomotive is necessarily a compromise between a number of conflicting factors. Certain criteria may, however, be set down, as follows:

1 In so far as the mechanical and electrical portions are concerned, the most economical design is that having the minimum number of axles consistent with an axle loading which does not overstress track or bridges on the particular railroad involved. Ordinarily this permissible axle loading may be assumed to be between 50,000 and 65,000 lb on rail per axle.

2 Track stresses will be reduced with a decrease in axle loading especially at high running speeds.

3 With a high axle loading and high running speeds, consideration must be given to the use of guiding trucks. Experience with high-speed electric locomotives has indicated that a running gear of the 2-C+C-2 type is the best one so far developed for this purpose.

4 In so far as the Diesel engines are concerned, the minimum number of cylinders necessary to do the work should be the most economical. This statement should be modified however by the following additional considerations:

(*a*) A road locomotive should preferably have at least two engines, so that in case of an engine failure en route at least one will be available to move the locomotive to a point where assistance can be secured.

(*b*) However, the cylinders must not be so large that they produce an engine too large and heavy for traction work.

(*c*) As the number of separate engines increase on a locomotive, the number of auxiliaries, such as governing systems, radiator systems, and lubricating-oil systems, increase.

(*d*) An increase in the number of cylinders above the minimum may mean an increase in the cost of maintenance on account of multiplicity of parts.

(*e*) The first cost of any Diesel engine is greatly affected by its production status and this will influence the choice of an engine to a considerable degree.

The foregoing major points may be elaborated upon as follows:

1 In order to determine how far it is feasible to reduce the number of axles on a locomotive to do a given job, it is necessary first to have an approximate idea of the horsepower and speed required for the job. The maximum output which can be obtained from a given axle depends upon the coefficient of adhesion and the weight on rails. Table 1 of this discussion shows for various speeds the approximate coefficient of adhesion based upon a wet rail and also for an assumed axle load of 50,000 lb, the tractive-effort horsepower, and the corresponding engine horsepower output (assuming 80 per cent transmission efficiency).

Knowing the total tractive effort and speed which should be developed, it is easy enough to determine from Table 1 the minimum number of driving axles required. The tabulation is based on 50,000 lb per axle as an illustration, and the values should be increased or decreased in proportion for the actual axle loading for the problem under consideration.

The locomotive should not be designed to operate continuously at the coefficients of adhesion shown; and to avoid a constant possibility of slippage, a margin of 10 to 15 per cent below these values is desirable for continuous operation. The coefficients of adhesion with a dry rail are somewhat greater than those shown in the table but they cannot always be counted upon.

It should be noted that no more work can be done with the axle of 50,000 lb weight on the rail than is shown by the table, and, when the total number of driving axles has been determined from the total horsepower requirements, any axles introduced in the design in excess of that amount are uneconomical but may be necessary to meet other requirements. Usually an even number of driving axles per locomotive is used as it lends itself to a wheel arrangement which permits the most satisfactory guiding to be provided.

2 As the axle loading is increased beyond 50,000 lb, more attention must be paid to the allowable bridge and track stresses, and the number of locations where these weights are not permissible increases.

3 As the axle loading is increased to permit fewer driving axles to be used, it becomes all the more necessary to provide guiding axles. The best running gear for high-speed-locomotive operation with a minimum number of driving axles which has so far been worked out is the 2-C+C-2 type.

In this design the weight per guiding axle should be approximately 50 to 75 per cent of the weight per driving axle in order to insure proper guiding.

4 The selection of the number of Diesel engines and cylinders to be used is a difficult problem to solve. It is believed that the statements made in items 4 (*a*) and (*b*) are self-evident and need no further explanation here.

In so far as item (*c*) is concerned, an increase in the number of engines, while it provides a greater amount of flexibility in the operation of a locomotive, also results in an increase in the number of auxiliary systems required and tends to increase the cost of maintenance.

Every separate engine involves a radiator system, a governor system, a lubricating-oil system, with the pressure, temperature, and speed limiting devices, and filters required for proper operation. The maintenance of separate devices of this nature increases the total cost of maintenance of the locomotive, and yet, if the advantages of separate power plants are to be realized, the engines must be kept separate in all respects. These parts very definitely require maintenance or they will give trouble as quickly as parts of the engines themselves.

Referring to item (*d*) relative to increasing the number of cylinders, which is recommended by the author as a means for reducing weight, and presumably first cost as well, the effect of this increase on the cost of maintenance should not be lost sight of, and particularly the cost of inspections which must be made at periodic intervals, regardless of whether repairs are required or not, in order to forestall failures in service. This tendency is indicated very clearly in Table 2 of this discussion, the first column of which is based upon actual cost records over a period of years of several switching locomotives each with an 8-cylinder 600-hp Diesel engine. The second column is an estimate of the costs

TABLE 1 AXLE-OUTPUT DATA

Speed, mph	Coefficient of adhesion, wet rail, per cent	50,000-Lb axle load		
		Tractive effort, lb	Tractive effort horsepower	Engine horsepower
0	25	12500	0	....
15	25	12500	500	625
20	21	10500	560	700
25	18.5	9250	620	775
30	16.5	8250	660	825
40	14.0	7000	750	940
50	12.5	6250	835	1040
60	11.0	5500	880	1100
70	10.0	5000	930	1160
80	9.0	4500	960	1200
90	8.5	4250	1020	1275

TABLE 2 COST OF MAINTENANCE OF DIESEL ENGINES AND AUXILIARIES

	One 600-hp engine	Six 100-hp engines
Total number of cylinders..	8	36
Cylinder diameter, in.....	8	4
Labor, inspection, per cent.....	10	45
Labor, repairs, per cent....	40	130
Material, per cent.....	50	85
Totals, per cent.....	100	260

which would be incurred if single 8-cylinder 600-hp engines were replaced by six 6-cylinder 100-hp engines.

The cost of maintenance of the Diesel engine and auxiliaries is approximately 45 per cent of the entire locomotive-maintenance cost.

In considering this problem, it must be borne in mind that a small cylinder has just as many associated parts, such as valves, injectors, pistons, and bearings, as a large cylinder, so that for the sizes liable to be encountered in traction work anyway, the cost of inspection per cylinder is practically independent of the size, and Table 2 is based upon this assumption.

The labor for repairs should be somewhat less per cylinder as the size is decreased, and it is believed to be a fair assumption that the 4-in. cylinder will require $^6/_8$ or $^3/_4$ as much labor for repairs. This is the basis used in the table.

The cost of material was estimated from actual prices of locomotive sets of those parts most often renewed, and the ratio between the total costs applied to the percentage for material in the first column. This cost is less per engine for the smaller engines but the cost per locomotive is more.

It will be noted that the estimated cost of maintaining the six 6-cylinder engines is approximately $2^1/_2$ times that of maintaining the single 8-cylinder engine. It is not presumed to state that these costs are absolutely accurate nor are they based on road-engine service, but they are indicative of a trend which should not be overlooked in giving consideration to increasing the number of cylinders. A comparison should be made along similar lines before deciding that the greater number of cylinders is desirable.

While some improvement in this ratio of maintenance costs might be made by using a smaller number of engines with the same number of cylinders, the change would be small as most of the cost ratio is based upon the maintenance of the individual cylinders.

Referring to item 4 (*e*), the first cost naturally is important as well as the cost of maintenance. However, unless there is a decidedly large reduction in first cost to be made by increasing the number of cylinders, the added cost of maintenance will soon cancel it out, as the cheaper first cost will affect only the material item in the total cost of maintenance. Naturally, the first cost will vary greatly depending upon the basis of production of the engines being compared. It is interesting to note, however, that both the engines used in the comparison of Table 2 were on a comparable production basis.

In conclusion, the writer believes that in the future the greatest reduction in weight and cost of Diesel engines and locomotives can be made by increasing the engine speed, and that after the war we will see a great deal of development along these lines which will have been stimulated by developments now taking place within the airplane industry. Such developments will perhaps make possible the installation of the total horsepower required in one cab, which is highly desirable from the weight- and space-saving standpoints, as well as permitting the most economical use of the material involved.

As the speed increases, the weights of parts decrease and, if proper provision is made for manufacture, the first cost should also be substantially reduced. However, the trend of maintenance as outlined should be borne in mind, and the number of cylinders kept to the minimum that will provide reliability in service and still keep the size down to one which can be manufactured economically. Also there are certain problems in the design of high-speed engines which do not exist in those of lower speeds and these must be considered in the engine design.

Even if extremely lightweight engines become available, it may not be necessary to use them, inasmuch as a certain minimum weight on drivers is required to do a given job as previously explained, and reduction of engine weight below that required for the minimum locomotive weight may not be economical. At present we are a long way from such a design but one can never tell how soon conditions may change.

Developments such as those mentioned can best be worked out by joint efforts of the manufacturers and the railroads, so that both may have a thorough understanding of the problems involved from each other's point of view.

COMMENT BY R. M. OSTERMANN[5]

To try to build Diesel locomotives of less weight per horsepower than present designs would be eminently correct in principle, and the author's general argument in that direction cannot be too strongly supported. It seems to the writer that an effort should be made to decrease the weight so much that all of it can be carried on drivers and can thus contribute to the tractive-effort possibilities of a locomotive design. Whenever enough progress is made in lightening the weight per horsepower of Diesel engines and their power-transmitting apparatus, adequate haulage characteristics should even be obtainable with a lesser number of driving axles and less adhesive weight than are embodied in present designs of road Diesels. Except for switching and other operations requiring many stops and starts, excessively large starting drawbar pulls are, relatively speaking, not nearly as important as largest possible drawbar pulls sustainable at the higher train speeds. A study of the curves denoting the total horsepower requirements of a train at various speeds on various grades and with adequate power reserve for reasonably fast acceleration at speed makes that clear. If, and when, the entire power plant can be made lighter, additional weight, cost, and maintenance savings may then well result from elimination of trucks, axles, etc., incidental to shortening the entire locomotive, without undue sacrifice of those operating characteristics which are desirable for long hauls.

Electrical multiple operation is unquestionably of greatest advantage for trains which must be very quickly accelerated from standstill, and when largest possible power at very low speeds is essential. However, it may well be argued whether one cannot afford to sacrifice this advantage in designing power for high-speed passenger and freight trains that make relatively few stops; provided such sacrifice involves tangible gains in locomotive investment and operating expense. It is also to be taken into consideration that, when a railroad, which operates over limiting grades of appreciable length, provides locomotives with excessively large drawbar pulls sustainable at very low speeds, the operators are frequently tempted to dispense with helpers on these limiting grades, and this may easily result in overheating of motors and generators, with attendant electrical troubles. This is to be understood as just a practical suggestion. The trouble can, of course, be avoided by engineers who are thoroughly aware of the time and load limitations which must be imposed upon electrical apparatus in order to prevent trouble. At the same time, it is probable that interference with an engineer's duties by automatic protecting devices, such as circuit breakers with time limit, would not be popular.

COMMENT BY A. H. WOOLLEN[6]

It should be pointed out that it is customary practice, when designing aluminum applications to locomotives, to use those aluminum commodities which are the cheapest to the maximum extent possible, and then to extend the use, if economical, into more expensive products. It is for this reason that the weight saving on the Pennsylvania Railroad P5 locomotive was 32,000 lb in the cab and apparatus deck. The weight saved in the cab of the locomotive discussed in this paper was only 8750 lb. Undoubtedly, this is a most conservative figure and could be greatly increased by proper application of aluminum alloys to the design of a locomotive cab of this type.

[5] Vice-President, Western Territory, The Superheater Company, Chicago, Ill. Mem. A.S.M.E.

[6] Engineer, Development Division, Aluminum Company of America, New Kensington, Pa.

Desiccation of Human Blood Plasma

COMMENT BY F. C. DEHLER[7]

The author is to be congratulated on this excellent presentation[8] which is of great general interest, as the desiccation of blood plasma, biological substances, and foodstuffs is playing an important role in our war effort. The subject is so completely and so well covered that there is little to be added or commented upon.

In the description of the physical adsorption method of desiccation, silica gel is mentioned as the solid adsorbent. It is possible that many reading this paper will ask the question; "What is silica gel?" Silica gel is a most inert prepared form of silicon dioxide having a very unusual porous structure. The pores are so small they cannot be seen by the most powerful ultra microscope, but their existence is known, for unlike ordinary silica, silica gel will drink in and hold about one half of its weight of water when in equilibrium with saturated vapor and still appear externally dry. Water vapor in coming into contact with silica gel is transformed or condensed to liquid water and held in the pores. This phenomenon called "adsorption" is entirely physical, no chemical reaction taking place between the water and the silica.

Silica gel is generally supplied in granular form. The particles are hard and rugged and neither break down to a powder nor go into solution as the silica gel becomes saturated. For this reason no corrosive or harmful compounds are given off that might in any way damage the product being dried or the equipment. In the process of drying blood plasma, the percentage of water adsorbed by the silica gel depends primarily upon its temperature, the lower the temperature the greater the amount adsorbed, hence the advantage of effective cooling mentioned by the author.

As the process of adsorption and subsequent regeneration of saturated silica gel is completely reversible, it is possible to use silica gel repeatedly for an indefinite period of time without loss in efficiency or capacity. This observation is based upon years of experience with silica gel in many types of equipment.

COMMENT BY R. C. WEBSTER[9]

In all of the methods described, with the exception of method 2, the vacuum pump is the activating instrument of the process and its efficiency is directly responsible for the success of the process. An oil-sealed vacuum pump is primarily designed as a dry vacuum pump, and its volumetric efficiency is plotted by manufacturers on this basis. Inasmuch as the ultimate vacuum produced by an oil-sealed vacuum pump is limited to the vapor pressure of the sealing oil, it is important that the sealing oil be kept in as clean and pure a condition as possible to give the pump its maximum performance. When operating under a normally dry condition, there is a certain amount of pollution of the oil in a pump from the water content of the air evacuated from the system. Thermal conditions in a pump in use for long periods of time keep the water content in the oil at a minimum so that oil changes are not too frequently required.

If there are conditions where excessive water vapor cannot be or is not trapped by some form of a condenser or trap prior to entry into the pump, oil pollution can be expected. The ultimate vacuum then obtainable by the pump is limited to the vapor pressure of the water. Some manufacturers have equipped their pumps with means for the mechanical separation of the water from the oil when excessive quantities of water occur. These mechanical separators do an excellent job in removing the greater percentage of the water from the oil. However, there is a fractional percentage of this water which remains in suspension and cannot be removed by mechanical means. It is this small percentage of water which directly affects the volumetric efficiency and ultimate vacuum obtainable by the pump.

Table 2 of the paper (or Table 1 of this discussion) indicates just what is expected of a vacuum pump when handling water vapor. It is evident that an excessive pump size is necessary when handling water vapor, as compared with a pump handling only the noncondensable gases. This means, referring to Table 2, that a pump operating at 1 mm pressure at approximately 0 F, handling water vapor, would have its effectiveness reduced to only 9 per cent. Whereas if the water vapor is condensed or trapped ahead of the pump and the pump is handling only the noncondensable gases, the effectiveness of this pump would be reduced to 40 per cent.

The design of a vacuum pump has a great influence on the volumetric efficiency as tabulated in column 5 of Table 2 and there is therefore quite a variation in these values as listed by various manufacturers. Take, for example, another single-stage oil-sealed vacuum pump, which we will call pump 2 and tabulate its values in column 5. This, of course, will change the values in columns 6 and 7 (see Table 1 of this discussion).

Referring again to the previous example wherein we had a pump operating at 1 mm pressure at approximately 0 F, when handling water vapor in pump 2, the effectiveness of the pump would only be reduced to 20 per cent, instead of 9 per cent, for pump 1. But when the water vapor is removed, the effectiveness of pump 2 is 90 per cent instead of 40 per cent in pump 1. It is obvious that, in this case, pump 2 can be a much smaller pump than pump 1. At lower pressures, the difference between pump 2 and pump 1 is even greater. A careful selection of the pump will reduce the initial investment as well as improve the operating conditions.

The removal of the water vapor in the gas stream from the processing chamber to the vacuum pump may be accomplished by several methods. Probably the most common method, when large quantities of water vapor are involved, is in the use of a primary and secondary condenser. To handle water vapor at the low pressures necessary in this type of process requires condenser-surface temperatures in the extreme low range of refrigeration, possibly as low as —80 F.

The condensing equipment is generally two large chambers submerged in a bath of dry ice dissolved in a fluid medium. As the process continues, the accumulation of the frozen water vapor on the surface of the primary condenser reduces the efficiency of that condenser, and the secondary condenser functions until there has been a complete dehydration of the plasma. As oil-sealed vacuum

TABLE 1 REVISION OF AUTHOR'S TABLE 2 TO INCLUDE PUMP NO. 2

1	2	5		6		7	
		Volumetric efficiency				Effectiveness factor	
Temp F	Pressure mm-hg abs	Actual per cent		Per cent of 4.5			
		Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
32	4.58	62	78	100	100	1.00	1.00
30	4.18	60	77	97	99	0.89	0.91
20	2.60	46	76	74	97	0.40	0.58
10	1.59	34	73	55	94	0.20	0.35
0	0.96	25	70	40	90	0.09	0.20
—10	0.56	17	66	27	85	0.04	0.11
—20	0.32	11	62	18	79	0.01	0.06
—30	0.18	7.5	57	12	73	0.005	0.027
—40	0.10	5.0	51	1	65	0.002	0.013

[7] The Davison Chemical Corporation, Baltimore, Md.

[8] "An Engineering Discussion of the Desiccation of Human Blood Plasma," by David C. Pfeiffer, MECHANICAL ENGINEERING, May, 1943, pp. 325–331.

[9] Sales Engineer, Kinney Manufacturing Company, Inc., New York, N. Y.

pumps reach their ultimate vacuum and the downstream flow from the process chamber to the pump approaches zero, experience has shown that there is a backflow of oil vapor from the pump. The secondary condenser also serves as a very effective trap in arresting completely the backflow of oil vapors which would be definitely detrimental to the product, if not removed. At the conclusion of the processing of each batch, it is necessary to defrost the condensing equipment before further processing can take place.

The use of adsorbent materials such as "silica gel" or "activated alumina" are effective and very efficient in the removal of water vapor, but the cold-trap principle of the secondary condenser safeguards the product against the possibility of any backflow of oil vapor from the vacuum pump.

In conclusion, it would seem that as oil-sealed vacuum pumps are primarily designed to operate as dry vacuum pumps, and until such time as a sealing medium which has no affinity for water is available for use in these pumps, the water vapor should be eliminated by suitable collection devices ahead of the vacuum pump. This will insure a maximum efficiency of operation and uniformity of pressure at a minimum cost of maintenance and initial expense.

AUTHOR'S CLOSURE

The author has no specific comments to make on Mr. Dehler's discussion. It is quite natural that a representative of the company manufacturing silica gel could elaborate on the properties of the product. We have found silica gel preferable to any other adsorbent used and definitely superior to any type of chemical desiccant now available. With reference to the useful life of this material, we have in operation at Baylor Hospital, Dallas, Texas, adsorbers which have been in continual operation for 4 years, being regenerated approximately twice weekly. They show absolutely no evidence of deterioration or loss of capacity or effectiveness. There is no reason to doubt that with proper care the life of silica gel will be indefinite.

Mr. Webster's revision of Table 2 of the paper emphasizes the necessity for making the proper selection of a vacuum pump, both as to capacity and manufacture. Not all vacuum pumps are equally suited to this type of work.

With reference to his suggestion of a two-condenser arrangement, this can, of course, be done with the adsorbers as well as with cold-surface condensers. There is a unit in operation in Kansas City, consisting of three 300-lb adsorbers, so arranged that any two can be operated in series while the third is being regenerated. This allows a "clean up" by the second adsorber in the series, thus preventing any vapor from reaching the vacuum pump. In the larger unit at Baylor, two adsorbers are used, so arranged that either can be put into operation or regeneration as desired. Each of these adsorbers is equipped with thermocouple junctions, placed at sections in the gel bed, so that the temperature of each section can be determined when desired. By reading these temperatures, the vapor travel through the adsorber can readily be determined. When the lowest thermocouple shows a rise in temperature, this indicates that the adsorber is nearing the end of its effectiveness and the adsorber is changed to a fresh one to prevent any possibility of water vapor getting over into the vacuum pump.

D. C. PFEIFFER.[10]

[10] Industrial Engineer, Dallas Power and Light Company, Dallas, Texas.

Making Curved Plywood

COMMENT BY G. H. CASE[11]

In connection with the paper by T. D. Perry,[12] the writer would like to have an answer to the following question:

Referring to the discussion of the omnidirectional pressure, where the pressure medium is also the heat medium, as in the case of steam, how is one varied without affecting the other?

In the hot-plate-press method of curing either film or liquid resins, temperature control and pressure control are absolutely independent of each other and under hand or automatic regulation. With saturated steam, the temperature and pressure follow the well-known law, as outlined under the properties of steam. For film resin, such as Tego, the 280 to 300 F usually employed would be accompanied by a gage pressure of from 35 to 52 psi. There may be cases in bonding where this would not be enough pressure, and to increase it would mean that the temperature would become too high. Also, for the case of curing some of the lower-temperature resins at 240 F, the pressure would drop down to 10 psi, which would be too low. With a hot-plate press, a temperature of 300 F can be obtained while the pressure is 200 psi; this being a common application.

[11] Williams, White & Co., Moline, Ill.

[12] "Flexible Pressure in Veneer and Plywood Work," by Thomas D. Perry, MECHANICAL ENGINEERING, June, 1943, pp. 417–424.

COMMENT BY RALPH CASSELMAN[13]

As usual, the author has covered the subject well with clear descriptions and well-chosen examples for illustrations.

As an extension to the subject, we should like to suggest consideration of two phases not included in the paper. These are the use of media other than fluids for pressure distribution and radio frequency for heating wood. While fluid pressure provides the means of distributing the pressure most uniformly, other media are sometimes more practical, easier to handle, and result in faster production with less equipment expense.

For instance, where the curvature is not great and where the direction of pressure is nearly normal to the surfaces, cushions of rubberlike materials are very useful. The operation can then be conducted in a press which for small parts allows more rapid handling. If the metal mold is cored for steam, heat transfer is more rapid than in autoclave operations.

The use of straps for application of counterpress has long been common practice in forming simple curves and is frequently very satisfactory.

Such methods are apt to be more efficient than bag molding for the molding of small sections in production operation. We mention this because bag molding has caught the general fancy so much in the past few years that it has been employed or tried in many applications for which other methods of molding are more suitable.

A portion of the plywood-molding field, in which working information is sadly lacking, is that wherein compound curves are formed and bonded with the heat provided by radio frequency. The subject has received some attention in a conversational way but very little actual working information appears to be available. Such information would be extremely desirable.

AUTHOR'S CLOSURE

Mr. Case's questions about the corresponding temperatures and pressures of steam are quite in order. However, most autoclave installations have an air compressor as an auxiliary source of pressure without heat. There is also another complication that tends toward excess heat, and that is the residual heat of the autoclave, when it is in continuous operation. One of the operating problems in any autoclave is to determine a heat-pressure relation that accommodates both the plywood construction and the adhesive that is used. It is not so difficult as it appears, since both the rubber bag and the outer layers

[13] Bakelite Corporation, Bloomfield, N. J.

of veneer retard the penetration of the heat to about the proper extent.

Mr. Casselman's comment regarding mechanical pressure applications, such as cushions or straps, as contrasted with bags, is quite appropriate. Wherever such simpler methods will meet the requirements of the product they should be used. In other words the use of the autoclave flexible-bag process should be only for shapes that cannot be made by simpler processes.

In so far as the author knows, little has been done in combining the technique of flexible-bag molding with that of applying high-frequency heat. Laboratory development is in progress, but it has not yet found industrial utilization. However, it gives promise of being an excellent and efficient combination.

T. D. PERRY.[14]

[14] The Resinous Products & Chemical Company, Philadelphia, Pa. Mem. A.S.M.E.

Iowa Coals in the National Emergency

COMMENT BY JOHN M. DRABELLE[15]

The paper[16] presented by Dr. H. L. Olin dealing with coals of the Central West and particularly of the state of Iowa clears up many geological and chemical questions in the minds of the users of these coals. The author and his associates have accomplished valuable results from their extensive work in the laboratory and in the boiler room, in the development of procedures for cleaning, storing, and burning such coals.

Coal operators should take note that a very small amount of rejection produces a material improvement in the quality of the coal, and that much more can be accomplished with coal as the most valuable of our fuels than is now being realized. Too many operators feel that their job is completed when the coal is mined. Undesirable impurities are allowed to remain in the fuel, for the consumer to contend with, which complicates both the storage and combustion of the coal.

COMMENT BY M. P. CLEGHORN[17]

Dr. Olin has handled this question in a laudable manner and gives one a good picture of Iowa coal and the problems in handling and burning it. He has said in effect: "Take out the fines in Iowa coal and a reasonably good fuel would result." There should be very little argument over this statement, since a larger percentage of the trouble-making elements appear in the fines.

The moisture, although high, is not in itself a serious objection. In fact, Iowa screenings burn better when more than the normal amount of moisture is present. It does, however, increase storage difficulties.

The nonuniformity in Iowa coal preparation is another objectionable feature mentioned. The mines are mostly small, the output from any one is thus restricted, and the preparation equipment limited. Demand for screenings used in stokers may overshoot the supply, and then one car may be largely mine sweepings and "bug dust," while the next may be crushed mine run containing much nut coal. Or one mine may call on another to make up the deficiency, thus perhaps changing the size and, perhaps, the burning and the slag characteristics as well. This variation creates a serious problem for the power-plant operator. While it is an economic problem with the mine operator, it has been suggested that with more particular care in preparation he might increase his sales and thus his income.

Storage of Iowa lump coal, or even 2-in. uniform-size nut coal is not difficult. However, with screenings, as now prepared, one had better "keep his fingers crossed" and expect heating even when the coal is correctly layered and packed. The Iowa Electric Light and Power Company has been mentioned. This company does store such coal, carefully placed, but always in small piles, thus giving evidence of some lurking fear that an unexpected fire might appear and spread. Underwater storage is the only sure method but that is not used as much as formerly.

Iowa coal on the average contains almost exactly the same percentage of volatile matter as fixed carbon. Southern Illinois coal contains more fixed carbon and less ash. Sulphur is higher in Iowa, running from 4 to more than 6 per cent. This sulphur, while not an absolute indicator, does suggest more possible clinker trouble, and such there is. The volatile matter requires a larger furnace volume and the clinkering tendency makes less heat release, lower furnace temperature, and more waterwall surface necessary.

Nevertheless, it is true that Iowa coal as at present prepared can be burned satisfactorily if equipment is correctly designed for it, if the quality stays put, and if the heat release is kept to a reasonable rate. At Iowa State College, we are burning such coal on a traveling-grate forced-draft stoker with an economizer and air heater at a gross efficiency of around 83 per cent. To force this unit with low-ash high-Btu coal would be tragic. It would be at least equally so were Iowa coal to be forced to burn in a furnace designed for a low-volatile high-softening-temperature-ash coal.

Yes, Iowa coal can meet any emergency demands in those furnaces designed for it. To go further than this will be to invite serious operating difficulties and high maintenance costs. Along with better or worse coal must come major changes in design, and these are limited in an emergency such as the present. In most of the state, Iowa coal will show a lower cost per 1000 Btu than any other fuel.

General Electric Co.

U. S. ARMY'S NEW ANTITANK WEAPON—THE "BAZOOKA"

(So called because of its resemblance to Bob Burns' weird musical instrument. It enables foot soldiers to fire projectiles powerful enough to combat tanks, pillboxes, and armored cars. It's small enough to be fired by one soldier but generally a second man loads it.)

[15] Consulting Engineer, Iowa Electric Light and Power Company, Cedar Rapids, Iowa. Mem. A.S.M.E.

[16] "Iowa Coals in the National Emergency," by H. L. Olin, MECHANICAL ENGINEERING, May, 1943, pp. 343–346.

[17] Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Glass: The Miracle Maker

GLASS: THE MIRACLE MAKER. By C. J. Phillips. Pitman Publishing Corporation, New York, N. Y., 1941. Cloth, 6 × 8⅞ in., 424 pp., illus., $4.50.

REVIEWED BY F. L. BISHOP[1]

THIS is a semitechnical book covering the entire field of the glass industry in a single volume. For the popular-science reader all but three chapters will be found readable and understandable, and Mr. Phillips has the knack of presenting his material so as to retain reader interest. For the civil, mechanical, electrical, or chemical engineer, or the architect and industrial designer the book offers a reasonably detailed coverage of the manufacture and uses of glass. The book should prove of great interest to the student engineer or beginner in the glass industry, as it covers all branches with equal skill.

It is not possible of course to cover the details of the various manufacturing techniques in such a volume but a wealth of references enables one to follow through on any interesting subject.

The book is adequately illustrated but here the reader may feel that the Corning Glass products are possibly a little overdone in comparison with the other products of the industry. This criticism cannot be made of the text material however, which is well balanced with the possible exception of the safety-glass industry.

[1] Professor of Physics, University of Pittsburgh, Pittsburgh, Pa.

The Spirit of Enterprise

THE SPIRIT OF ENTERPRISE. By Edgar M. Queeny. Charles Scribner's Sons, New York, N. Y., 1943. Cloth, 5½ × 8 in., 267 pp., $2.

REVIEWED BY J. M. JURAN[2]

THE spectacle of a businessman extolling the virtues of free enterprise while denouncing New Deal planning and bureaucracy is hardly a rare phenomenon. However, when a leading industrialist has undertaken an earnest search for facts and light, when he presents his case in an atmosphere of dignified frankness, when his reasoning is for the most part many stages beyond the primitive one of name-calling, and when he writes with the virile style of a free man speaking his own mind, the result warrants more than passing notice.

This is not to say that in the process the author understates the claims regularly made by the advocates of individualism and of free enterprise. On the contrary his enthusiasm in this area frequently reaches the top levels. However, he supports this enthusiasm with a logic and a bibliography far beyond the common run, as though his studies had given him a factual basis to provide demonstrable support for what he had always believed.

His findings as to why so correct a system has spent a decade in the doghouse are by no means so sharply outlined. Mr. Queeny's explanatory cauldron contains the mistakes of individualism, the undigested immigrants of the metropolitan centers, the development of pressure groups, the depression, Thorstein Veblen, and other ingredients, the entire brew considerably obscured from view by a vapor of vagueness. When, for example, the author assigns to Veblen a role as the prophet whose words have become the Mein Kampf of the New Deal, one wonders how many New Dealers have ever heard of Veblen.

The attack on the New Deal is on a broad front—the methods used in coming to power, the conduct of affairs ever since, and the plans for the future. Evidently the author had the fortitude to study all the testimony and exhibits of the hearings of Temporary National Economic Committee, for he devotes much time to exposing the "bogeys" of this undertaking.

With drastic departure from the thinking of the orthodox industrialist, Mr. Queeny is concerned but little with the deficiencies of the New Dealers as individuals. On the contrary, he considers them but victims of their environment. "Not for one moment is this criticism of bureaucracy meant to impute that government officials are not of as high character as those engaged in private enterprise . . . . we are merely comparing how two alternative systems (private enterprise and state control) vary in the different responses obtained from distinguishing qualities of human character. . . . . All (Republicans, Democrats, and New Dealers) respond to bureaucratic influence in about the same way, and if managers of private enterprise entered bureaucracy, their response to its influences would parallel that of our present (government) officials."

This is clearly an incisive observation, as far as it goes. The associated analysis of the nature of Bureaucracy is, as far as it goes, equally incisive. Mr. Queeny makes a swift tour of the usual bureaucratic landmarks, red tape, delay, inaction, buck-passing, inefficiency, and so on through the catalogue. He also includes some characteristics that are obscure to the less keen observer. And again with incisiveness, "These same forces would operate in private enterprise except for competition." (*sotto voce:* And in a private monopoly do they indeed operate?)

So far so good. In the area analyzed the author has undoubtedly scored well. But much remains unanalyzed. For example, if it be admitted that the characteristics of bureaucracy are as stated by Mr. Queeny, does it follow that these ills are incurable? Must scientific management, which has done so much for Industry, be an eternal stranger to government? If Mr. Queeny is indeed comparing two systems, is he warranted in comparing the present system *at its going level of effectiveness* with his proposals *at their optimum level of effectiveness?*

Again, Mr. Queeny dwells on the unjust spectacle of business under attack. "Answers by business, if made at all, are usually factually uninteresting, punctiliously phrased by attorneys." He points out that the medical profession (for example) might, by a well-laid plan of propaganda, be crucified as well. "Could lawyers, labor, politicians, the church, the press, or even the New Deal itself survive a searching inquiry?" Here Mr. Queeny may well take a leaf out of the politician's primer, for in the political world it is elementary that you must seize and retain the initiative. Once you are seriously on the defensive you are lost.

The author's proposals for the world of tomorrow include retention of many of the reforms of the last decade, but under new management. There are, however, some notable additions to the list. There

[2] Assistant Administrator, Office of Lend Lease Administration, Washington, D. C. Mem. A.S.M.E.

is further a disposition to junk some of the existing administrative Boards and to return to the judicial process.

Just how free enterprise is to get back into the saddle is not touched on, beyond the hope that the elections will achieve this. The author may have considered this vital step as outside the scope of his book. It would have added materially to the effectiveness of his thesis had he analyzed this problem. When one is out of power a precise analysis of the other fellow's errors is just so much rhetoric unless it is part of a program for action. The politician who may never "have seen the inside of a factory" knows as a fundamental that acquisition of political power is not a matter of letting nature take its course.

Despite the presence of dim areas and his omission of a procedural bridge to the greener pastures ahead, Mr. Queeny has produced an argument which illuminates much of this much debated area. His earnest searches in the literature and in his own mind are well reflected in his exemplary level of sincerity. Surely no superficial examination could have attained such a level.

The proponents of a full or even partial return to the rules of *laissez faire* will find in this book a new advanced base from which to continue operations.

Essentials of Industrial Health

ESSENTIALS OF INDUSTRIAL HEALTH. By C. O. Sappington. J. B. Lippincott Company, Philadelphia, Pa., 1943. Cloth, 6 × 9 in., 626 pp., $6.50.

REVIEWED BY THEODORE HATCH[3]

THE problems of health maintenance in industry and the concept of the over-all functions of an industrial health service have broadened to a marked degree from the limited beginnings twenty-five years and more ago. This expansion, which has been rapid during the past decade, is clearly indicated by the general outline and the material covered in the present volume. Early books in the field of industrial medicine were limited, for the most part, to discussions of industrial injuries. Later there appeared volumes on occupational diseases and some were even restricted to the consideration of a single industrial poison or hazard. These books reflected the interest in the field at the time they were written, as the present volume indicates the point of view today. The modern field of industrial medicine considers in addition to the problems of industrial injury and occupational diseases the over-all problem of health maintenance among industrial workers. Sickness and absenteeism among workers without regard to the cause is recognized today as a major factor in determining the efficiency and cost of production. It is recognized further that the causes of industrial origin constitute a minor part and that the largest percentage of time lost by industrial workers results from damaging factors which are common to the whole population. Early concepts of industrial medicine emphasized the necessity for establishing a definite casual relationship between the injury or illness and a particular hazard within the industrial establishment. From a legal point of view this is still true but in the program of a modern health service recognition is also given to the less clear-cut relationships between the health of the worker and plant hygiene generally and even community hygiene. Thus it is seen that volume with the broad title "Essentials of Industrial Health" must necessarily consider more than the causes and prevention of occupational diseases and industrial accidents.

The subject matter of this volume is presented in three parts: Part 1, Industrial Health Administration; Part 2, Industrial Hygiene and Toxicology; and Part 3, Industrial Medicine and Traumatic Surgery. In Part 1, the historical development of industrial health services is followed by a consideration of occupational morbidity and mortality and in the following three chapters with an over-all discussion of the scope and objectives of modern health service, the function and qualifications of industrial physicians, and the organization of the industrial medical department. The analysis of causes and duration of loss of time in industry shows clearly the relative importance of occupational causes as compared with those that are present within a community as a whole. The author emphasizes the incompleteness of statistics on the incidence of industrial illness and mortality. With respect to the distribution of industrial health services, the sharp contrast between large and small industrial units is pointed out, the latter group having, at the present time, very limited services. Managers of smaller establishments will find the author's discussion of the opportunities for health servic in their plants most valuable.

The second section consists largely in a broad outline of the problems of industrial hygiene and toxicology with relative brief discussion of the principles of control. Since this volume was prepared from the point of view of the over-all problem, the author has wisely refrained from extending the book to include detailed discussions of specific occupational health hazards. These are treated more fully in other volumes covering particular problems. The third section, on "Industrial Medicine and Traumatic Surgery," also considers the problem from this broad point of view. One finds no detailed discussion of medical and surgical technics, but rather the consideration of such basic questions as "The Worker and the Job," "Workmen's Compensation and Rehabilitation," etc.

The specialist, already engaged in the field of industrial health maintenance, will find little in this volume that is new. On the other hand, as an introduction to the field, it presents an over-all picture of the broad objectives of industrial health service which should be understood from the beginning. The volume is recommended not only to industrial physicians and hygienists, but should prove to be a most valuable reference work for industrial managers who are concerned with a critical problem in these days of maximum industrial production: the reduction of sickness and absenteeism and the maintenance of maximum productive efficiency in industry.

[3] Lieut. Colonel, Sanitary Corps, Executive Officer, Armored Medical Research Laboratory, Fort Knox, Ky. Mem. A.S.M.E.

Books Received in Library

AIR TRANSPORT NAVIGATION for Pilots and Navigators. By P. H. Redpath and J. M. Coburn. Pitman Publishing Corp., New York, N. Y., and Chicago, Ill., 1943. Cloth, 6 × 9½ in., 612 pp., illus., diagrams, charts, tables, $5. The basic information contained in this comprehensive work is useful to the private pilot as well as to the transport pilot and navigator for whom it is primarily intended. Fundamental theories are explained, necessary instruments are described, and practical procedures are discussed for establishing and flying a course by the various methods available. The combination of dead reckoning and radio direction finding is of particular interest. Routine navigation practice, including sample log sheets, and airline flight dispatching are also covered. A wealth of ready-reference information is provided.

A.S.T.M. STANDARDS ON PLASTICS, sponsored by A.S.T.M. Committee D-20 on Plastics; Specifications, Methods of Testing, Nomenclature, Definitions. American Society for Testing Materials, Philadelphia, Pa. May, 1943. Paper, 6 × 9 in., 375 pp., illus., diagrams, charts, tables, $2. (A.S.T.M. members, $1.50.) The specifications, methods of test, recommended practices, nomenclature, and definitions relating to plastics which have been approved by the Society are brought together in one volume for convenience.

AIRCRAFT HYDRAULICS. By H. W. Adams. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England. 1943. Cloth, 6 × 9½ in., 159 pp., diagrams, charts, tables, $1.75. This text deals with the basic principles and general rules that govern the design

of hydraulic systems for aircraft. The treatment is a practical one, aimed to enable the engineer to become a specialist in this field as quickly as possible. Although intended specifically for aircraft engineers, the book should be useful to designers of hydraulic systems for other purposes.

AIRCRAFT MATHEMATICS. By S. A. Walling and J. C. Hill. Revised edition. The University Press, Cambridge, England; The Macmillan Co., New York, N. Y., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 186 pp., diagrams, charts, tables, $1.75. A brief textbook covering the mathematics required for Air Training Corps cadets in Great Britain, adapted to American usage and terminology in this edition.

AMERICA'S GREATEST INVENTORS. By J. C. Patterson. Thomas Y. Crowell Co., New York, N. Y., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 240 pp., diagrams, $2. This book tells briefly the lives and inventions of the eighteen men who were selected as America's greatest inventors in connection with the celebration, in 1940, of the sesquicentennial of the United States patent law. The list is an impressive one. The biographies are interesting, accurate, and popular in style.

ANALYSIS OF CONTINUOUS FRAMES BY GRAPHICAL DISTRIBUTION OF MOMENTS. By A. A. Eremin. Apply to author and publisher, A. A. Eremin, 1541—37th St., Sacramento, Calif., 1943. Paper, $8^1/_2 \times 11$ in., 17 pp., diagrams, charts, tables, lithographic, $2. This pamphlet presents a graphical method for the distribution of moments in continuous beams or rigid frames. The method is claimed to be as exact as algebraic methods and to be much less time-consuming. Numerous illustrative examples are given.

DYNAMICAL ANALOGIES. by H. F. Olson. D. Van Nostrand Co., Inc., New York, N. Y., 1943. Cloth, $5^1/_2 \times 9$ in., 196 pp., diagrams, charts, tables, $2.75. This book deals with the analogies between electrical, mechanical rectilineal, mechanical rotational, and acoustical systems. By means of analogies the knowledge of electrical circuits may be applied to the solution of problems in mechanical and acoustical systems. The subject matter is developed in stages from the simple element to complex arrangements of multielement systems. The text assumes a familiarity with the elements of alternating circuit theory and physics.

ELECTRICAL AND RADIO DICTIONARY, including Symbols, Formulas, Diagrams, and Tables, prepared by C. H. Dunlap and E. R. Hahn. Revised and enlarged edition. American Technical Society, Chicago, Ill., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 110 pp., diagrams, tables, $1. The main dictionary section of this book is separated into two parts, one for electrical terms, and one for radio terms. In addition to these there are a brief glossary of electronic terms, a list of electrical symbols with pictorial explanations, and several pages of useful reference data.

ENGINEERING PROBLEMS ILLUSTRATING MATHEMATICS. By J. W. Cell. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 172 pp., diagrams, charts, tables, $1.75. This text contains a collection of problems for students of college algebra, trigonometry, analytical geometry, and differential and integral calculus. It is intended for use in junior and senior engineering courses and aims to give students better understanding of the uses of mathematics than is obtained from purely formal exercises by presenting practical problems of technological and industrial application. The work is a project of the Society for the Promotion of Engineering Education.

FERROMAGNETISM, the Development of a General Equation to Magnetism. By J. R. Ashworth. Taylor & Francis, London, England, E.C. 4, 1943 printing, first published in 1938. Cloth, $5^1/_2 \times 9$ in., 97 pp., charts, tables, 7s 6d. The contents of this book are confined closely to the development of a ferromagnetic equation based on the analogy of the fluid laws. This development depends, to a considerable extent, upon the application of the Van der Waal's equation of state to magnetism. The material in the book is a revised and co-ordinated presentation of the results of experiments published over a long period in various English scientific journals.

FUEL TESTING, Laboratory Methods in Fuel Technology. By G. W. Himus. Leonard Hill Limited, 17 Stratford Place, W.1, London, England, 1942. Second edition. Cloth, 6×10 in., 288 pp., illus., diagrams, charts, tables, 21s. The methods of testing presented in this manual are those specified by the British Standards Institute, the Fuel Research Board, and the Institute of Petroleum. The treatment, however, is far wider than a mere presentation of analytical methods. General principles are discussed at some length, and much general advice on the selection of fuels is included. While chief attention is given to coal, oil and gas are also treated.

FUNDAMENTALS OF ELECTRICITY. By W. H. Johnson and L. V. Newkirk. The Macmillan Co., New York, N. Y., 1943. Linen, $8 \times 11^1/_2$ in., 212 pp., illus., diagrams, charts, tables, $2. This pre-induction course in electricity is prepared in accordance with Army specifications for skilled training. It covers basic magnetic and electrical theory, describes the construction and operation of typical electrical apparatus such as storage batteries, meters, motors, rectifiers, etc., and illustrates all topics by means of effective photographs and diagrams. Many practical laboratory experiments are included.

FUNDAMENTALS OF SHOPWORK. By W. H. Johnson and L. N. Newkirk. The Macmillan Co., New York, N. Y., 1943. Linen, 8×11 in., 200 pp., illus., diagrams, charts, tables, $2. The first two chapters of this elementary text classify and describe essential shopworking tools. Succeeding chapters discuss measuring and gaging, woodworking and metalworking practice, wiring and wire splicing, ropes, and block and tackle rigging. Photographs and diagrams are effectively used to illustrate practical points. The book has been planned to meet the Army specifications for skilled training.

HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1943, Volume 21. American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 1160 pp. + Roll of Membership, 90 pp., illus., diagrams, charts, tables, $5. The 1943 edition of this well-known reference book follows the form of preceding ones but has been carefully revised and, in part, rewritten. A chapter on abbreviations, symbols, and standards has been added, and an appendix discusses emergency war practices now in use.

INDUSTRIAL PRODUCTION ILLUSTRATION for Students, Draftsmen, and Illustrators. By R. P. Hoelscher, C. H. Springer, and R. F. Pohle. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Stiff paper, spiral loose-leaf binding, 9×11 in., 172 pp., illus., diagrams, charts, tables, $3.50. The purpose of this text is to present a thorough, comprehensive, theoretical treatment of pictorial drawing, together with practical advice on its uses. Lettering, orthographic projection and sketching, axonometric projection and sketching, oblique projection and sketching, perspective, engineering delineation, and shading are discussed, with special reference to the needs of those engaged in the machine, aircraft, and shipbuilding industries.

INTRODUCTION TO ATOMIC PHYSICS. By S. Tolansky with a foreword by Sir L. Bragg. Longmans, Green & Co., London, England., New York, N. Y., Toronto, Canada, 1942. Cloth, $5^1/_2 \times 9$ in., 343 pp., illus., diagrams, charts, tables, $4.50. The aim in this book is to supply a broad survey of the development of modern atomic physics for students who have completed a first year of college physics and are proceeding further. The treatment is descriptive and calls for little mathematical knowledge.

LABORATORY MANUAL FOR CHEMICAL AND BACTERIAL ANALYSIS OF WATER AND SEWAGE. By F. R. Theroux, E. F. Eldridge, and W. L. Mallmann. Third edition, revised and enlarged. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 274 pp., diagrams, charts, tables, $3. This manual provides the engineer with procedures for all the usual tests made in water and sewage plant laboratories as well as with many special tests required for stream surveys and trade water analysis. A particular feature is the manner of presentation, which permits the student to follow the methods of analysis by definite step-by-step procedures. In this third edition a section dealing with the testing of boiler waters has been added.

MANUAL of INDUSTRIAL HYGIENE and Medical Service in War Industries, issued under the Auspices of the Committee on Industrial Medicine of the Division of Medical sciences of the National Research Council; prepared by the Division of Industrial Hygiene, National Institute of Health, United States Public Health Service; edited by W. M. Gafafer. W. B. Saunders Company, Philadelphia, Pa., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 508 pp., charts, tables, $3. Military demands have withdrawn from industry many experienced industrial physicians, engineers, and hygienists. This book is issued to assist physicians who must replace these losses and deal with the health problems of workers in war industries. It brings together in a single volume the essentials of the subject, covering the organization and operation of plant hygienic services, the prevention and control of disease in industry, and the problem of manpower in industry.

MARINE ENGINEERING. By J. M. Labberton. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6×9 in., 439 pp., illus., diagrams, charts, tables, $4. This textbook is based upon courses given in the graduate division of the College of Engineering of New York University and to graduate engineers in ship and navy yards. It is intended especially for electrical and mechanical engineers who are entering this special field. Both steam and Diesel-driven ships are considered.

(The) MATHEMATICS of PHYSICS and CHEMISTRY. By H. Margenau and G. M. Murphy. D. Van Nostrand Co., Inc., New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 581 pp., diagrams, charts, tables, $6.50. This book brings together within a single volume those parts of advanced mathematics that form the tools of the modern worker in theoretical physics and chemistry. The subjects selected for treatment are those believed to be the most important for these workers, and the treatment of these subjects is full enough for practical purposes.

MECHANICAL VIBRATIONS, Theory and Applications, an introduction to practical dynamic engineering problems in the structural field.

By R. K. Bernhard. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1943. Cloth, 6 × 9½ in., 139 pp., illus., diagrams, charts, tables, $3. This presentation is intended especially for those who have not studied dynamics extensively, and who wish a presentation without advanced mathematics. The needs of structural engineers are given special attention. Part one discusses the physical phenomena and their significance in engineering dynamics; part two, methods of measuring vibrations. There is a bibliography.

MECHANICAL WORLD YEAR BOOK 1943. Emmott & Co., *Mechanical World*, Manchester and London, England. Cloth, 4 × 6½ in., 360 pp. + 260 pp. ads. and index, illus., diagrams, charts, tables, 2s 6d. This yearbook, now appearing for the fifty-sixth year, provides a pocket-size manual of information on machine-shop practices, light alloys, plastics, bearings, steam boilers, turbines, internal-combustion engines, welding, and other topics of interest to manufacturers and mechanical engineers, together with much tabular matter.

METALLURGICAL PROBLEMS. By A. Butts. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Fabrikoid, 6 × 9½ in., 446 pp., illus., diagrams, charts, tables, $4. This is the second edition of a work published in 1932 with the title, "A Textbook of Metallurgical Problems." The purpose is to provide practical training in the calculations required in metallurgy, in such operations as the smelting of ores, drying, roasting, and calcining in coke-making and in electrolytic and hydrometallurgical processes. The new edition has been carefully revised; the data and the metallurgical processes have been brought up to date and new problems introduced.

MICROMERITICS, the Technology of Fine Particles. By J. M. DallaValle. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1943. Cloth, 6 × 9½ in., 428 pp., diagrams, charts, tables, $8.50. This work is intended as a general guide to the behavior and characteristics of fine particles, and thus treats a subject of interest to workers in many fields of science and engineering. Methods of particle measurement, size distribution, and packing arrangements are considered, and a general theory concerning the physical properties of fine particles is presented. Industrial applications of the subject matter, as in the transportation of fine materials, in fine grinding and the treatment of dust and smoke, are discussed.

MISCELLANEOUS PHYSICAL TABLES—PLANCK'S RADIATION FUNCTIONS AND ELECTRONIC FUNCTIONS, prepared by the Federal Works Agency, Work Projects Administration for the City of New York, N. Y., conducted under the sponsorship and for sale by the National Bureau of Standards, Washington, D. C., 1941. Cloth, 8 × 11 in., 58 pp., charts, tables, $1.50. These tables give the values of Planck's radiation functions to five significant figures, and of the electronic function to six figures.

MODERN MARINE ENGINEER'S MANUAL, volume 2, edited by A. Osbourne and others. Cornell Maritime Press, New York, N. Y., 1943. Fabrikoid, 5 × 7½ in., 1200 pp., paged in sections, illus., diagrams, charts, tables, $4. The second and final volume of this work is, like the first, prepared by a number of specialists. It concludes the study of engines by a section on marine Diesel engines. Other sections deal with marine refrigeration, heating, ventilation, insulation, steering gear, deck machinery, electricity, instruments, propellers, tests, and trials. A collection of useful tables is given. The book is a practical guide for the operation and maintenance of ship machinery.

OFFICE LIBRARY OF AN INDUSTRIAL RELATIONS EXECUTIVE. (Bibliographical Series No. 72.) Prepared by H. Baker. Fourth edition. Princeton University, Industrial Relations Section, Princeton, N. J., 1943. Paper, 6 × 9 in., 33 pp., $0.40. This publication contains a list of books and pamphlets suggested as a useful library for an industrial relations executive. Approximately 150 items are listed under the broad headings of general works, specific personnel problems, trade unions, and collective bargaining, labor legislation, social insurance, and additional sources of information.

PLANE AND SPHERICAL TRIGONOMETRY with Tables to Four Places of Decimals. By W. C. Brenke. The Dryden Press, Inc., New York, N. Y., 1943. Cloth, 5½ × 8½ in., 269 pp., diagrams, charts, tables, $1.90. This book is a rewriting of the author's "Elements of Trigonometry," with amplified explanations and greater use of illustrative worked examples. Problems of mensuration, surveying, and sailing are given special attention, as are the applications of spherical trigonometry to navigation. The use of the mil unit of angle is shown.

PRACTICAL PHYSICS. (Industrial Series.) By M. W. White, K. V. Manning, R. L. Weber, and R. O. Cornett; prepared under the direction of The Division of Arts and Science Extension, Pennsylvania State College. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9½ in., 365 pp., illus., diagrams, charts, maps, tables, $2.50. This elementary, practical, and abbreviated text in introductory general physics is designed to meet a specific need created by the pressure of wartime conditions. Primary emphasis is placed upon the basic principles of those portions of physics of immediate use in war industry.

PRODUCTION ENGINEERING, JIG AND TOOL DESIGN. By E. J. H. Jones. Chemical Publishing Co., Brooklyn, N. Y., 1941. Fabrikoid, 5½ × 9 in., 304 pp., illus., diagrams, charts, tables $5. Basic tool elements and general principles of jig and fixture design serve as the groundwork for succeeding chapters presenting specific design procedures. The designs are related to the most economical form for the production of varying quantities of an article and embrace a wide variety of machines and processes. A final chapter deals with air-operated fixtures.

QUESTIONS AND ANSWERS FOR MARINE ENGINEERS, Book VI—Water Treatment, Corrosion, and Safety Rules. Compiled by H. C. Dinger. *Marine Engineering and Shipping Review*, Simmons-Boardman Publishing Corporation, New York, N. Y., 1943. Paper, 5 × 8½ in., 136 pp., tables, $1. These questions and answers deal with the problems of feedwater treatment, corrosion, lubrication, and fire prevention as they confront the marine engineer. They have been selected from those that have appeared during recent years in the *Marine Engineering and Shipping Review*. In addition the pamphlet gives information on obtaining marine-engineering licenses and recent examination questions.

QUESTIONS AND ANSWERS FOR MARINE ENGINEERS, Book VII—Diesel Engines—Electrical Equipment. Compiled by H. C. Dinger. *Marine Engineering and Shipping Review*, Simmons-Boardman Publishing Corporation, New York, N. Y., 1943. Paper, 5 × 8 in., 130 pp., diagrams, tables, $1. These questions and answers, compiled from *Marine Engineering and Shipping Review*, cover many practical questions which have puzzled marine engineers in operating and maintaining marine Diesel engines and the electrical equipment found on small ships.

QUESTIONS and ANSWERS for MARINE ENGINEERS, Book VIII—Materials and Calculations—Handy Tables. Compiled by H. C. Dinger. *Marine Engineering and Shipping Review*, Simmons-Boardman Publishing Corporation, New York, N. Y., 1943. Paper, 5 × 8½ in., 159 pp., diagrams, charts, tables, $1. This is the final collection of questions and answers culled from recent files of the *Marine Engineering and Shipping Review*. The contents are a miscellany of problems relating to the calculation of strength and of tank capacities, to the properties of metals, the treatment of steel, and to protective coatings.

(The) REFRIGERATED DATA BOOK and Catalog, fifth edition, 1942. A.S.R.E., New York, N. Y. Fabrikoid, 6½ × 9½ in., 518 pp., Catalog Section, 160 pp., illus., diagrams, charts, tables, $4 in U.S.A. ($4.50 other countries). This edition of this well-known reference book has been thoroughly revised and reset in more readable form. It is substantially a revision of the 1939 edition, being devoted chiefly to the basic principles and data of refrigeration and to the major kinds of refrigerating and air-conditioning machinery.

ROAD TESTS OF AUTOMOBILES USING ALCOHOL, GASOLINE FUELS. Iowa Engineering Experiment Station Bulletin 158. By R. G. Paustian. Iowa State College, Ames, Iowa, 1942. Paper, 6 × 9 in., 56 pp., illus., diagrams, charts, tables, gratis. This bulletin presents the results of careful comparative tests of cars using alcohol-gasoline blends with those using gasoline alone. The fuel mileage, accelerating ability, antiknock properties, and oil consumption with alcohol-gasoline blends are reported in detail. Blends containing not more than twenty per cent of alcohol were found to be satisfactory.

XV. SHIFT SCHEDULES FOR CONTINUOUS OPERATION. (Industrial Relations Digests.) Princeton University, Industrial Relations Section, Princeton, N. J., May 1943. Paper, 7 × 10 in., 8 pp., tables, $0.20. This digest of current practice has been prepared for the use of managements facing the need for rearrangement of schedules on a 48-hour basis. It is based on information received from representative companies and covers three-shift schedules and also the two-shift schedule with three crews.

SMALL ARMS MANUAL. By J. A. Barlow and R. E. W. Johnson. Revised edition. John Murray, London W., England, 1942. Flexibles, 4 × 5½ in., 232 pp., diagrams, tables, $1. The major part of this manual is devoted to detailed instructions for the operation, taking-down, and assembling of various types of small arms, chiefly British. The classes covered are rifles, light machine-guns, machine carbines, revolvers, and automatic pistols. Ammunition and special features are noted, and there is brief information on the functions in battle of these types of weapons.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. to Meet With Engineering Institute of Canada at Toronto, Canada, September 30-October 2

Tentative Program of Technical Sessions Announced

THE 1943 Fall Meeting of The American Society of Mechanical Engineers will be held jointly with The Engineering Institute of Canada, September 30, October 1 and 2, 1943, at the Royal York Hotel, Toronto, Canada. Officers of the E.I.C. met with the A.S.M.E. Committee on Meetings and Program in New York recently and as a result the A.S.M.E. Council has approved the invitation to meet jointly with the Canadian engineers. The officers of the E.I.C. decided that the time was propitious for a meeting of the members of the two societies during this important period of engineering production for the war effort.

Fortunately the schedule of the National Meetings of the A.S.M.E. was in a condition to make it possible to accept this invitation without interfering with other plans. Toronto was selected as the meeting place because of its traveling convenience and accessibility to a large percentage of A.S.M.E. members, both in Canada and the United States, and because the Royal York Hotel offers unusual facilities for a meeting of this character.

Make Reservations at Once

Whereas full details of the program cannot yet be given, sufficient information is available to enable members to make a decision as to the value and desirability of their attending this meeting. Members should make reservations at the Royal York Hotel as well as travel arrangements now so that they will not be disappointed by undertaking to do this too close to the meeting dates.

The Canadian practice of scheduling sessions so that all the members may be in attendance at a single session instead of being broken up into several groups meeting concurrently will be followed. The six main sessions will deal with the particular problems of mechanical engineering as related to production of material for use in the war effort.

E. G. Bailey to Talk on Steam Power

On Thursday morning, September 30, the meeting will open with a session on steam power with E. G. Bailey, vice-president, The Babcock and Wilcox Company, New York, as the speaker representing the United States. Another speaker will present the Canadian point of view. The discussion will bear on the changes in steam-generation principles, particularly in marine equipment, as brought about by the war, and their resultant effect on power generation in the future.

At luncheon that day the speaker will be Brigadier General Julian S. Hatcher, Chief of the Field Service Division, Office of Chief of Ordnance, Washington, D. C.

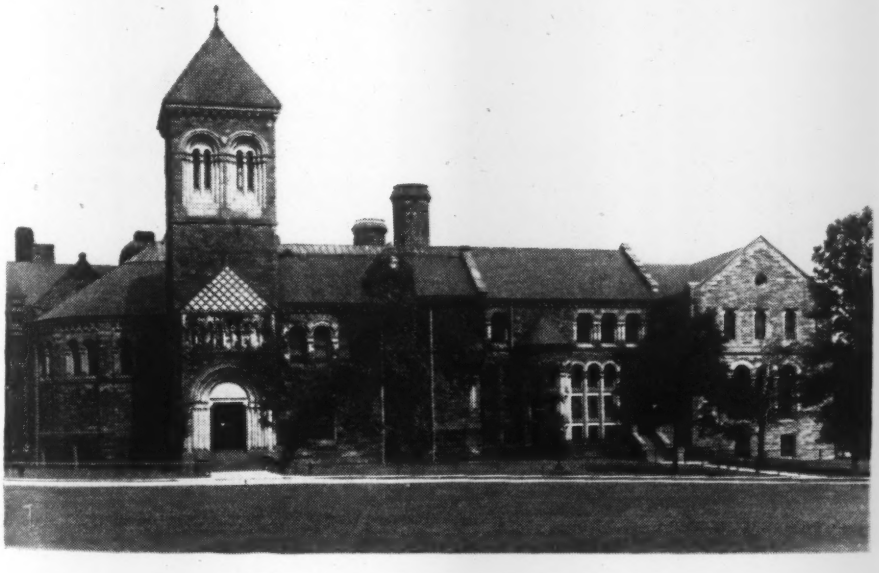
ROYAL YORK HOTEL, HEADQUARTERS FOR A.S.M.E.-E.I.C. MEETING

Transportation Subject of Session

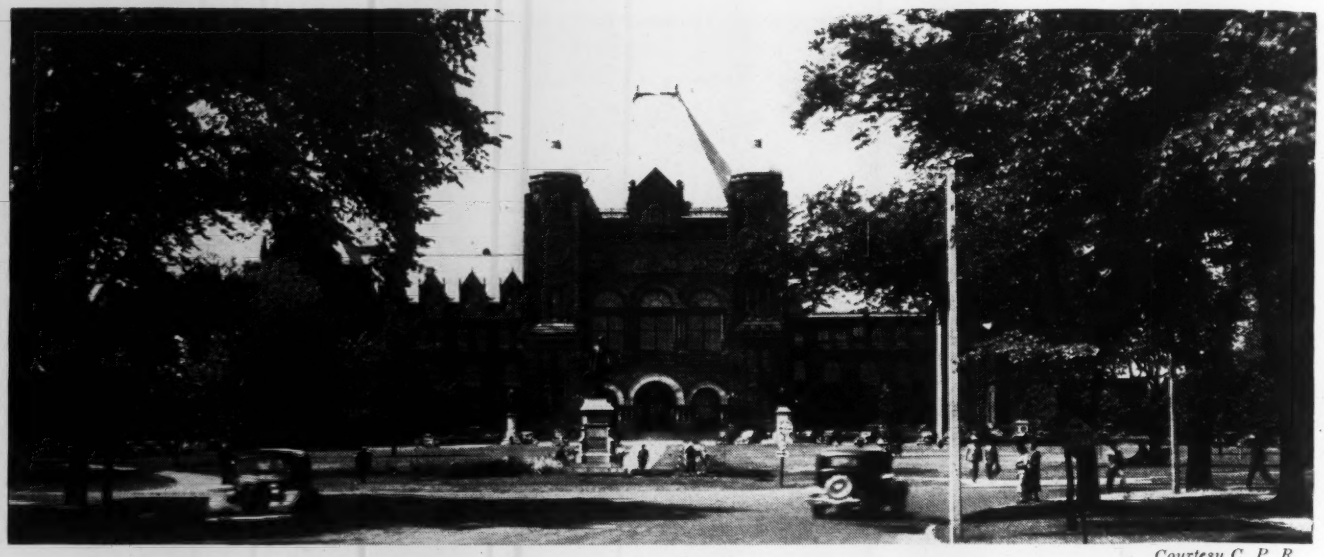
The afternoon session will feature transportation problems. It is expected that the Canadian speaker will give a broad economic treatment of the Canadian railway problem while the speaker from the United States will deal with air transportation and railroad equipment developed during wartime and their effect on peacetime transportation.

Evening Session on Postwar Planning

Thursday evening a session on postwar planning will be held and the discussion will undertake to describe the necessary components of postwar planning by government and industry, and the need for co-ordination between these components as well as the limit of their respective fields. Ralph E. Flanders, past-president A.S.M.E., president, Jones & Lamson Machine Co., Springfield, Vt., and chairman, Committee on Economic Development, will present the American point of view; and the principal Canadian speaker will be Dr. F. Cyril James, principal of McGill University, who has been selected by the Prime Minister of Canada for the important post as chairman of an advisory committee on postwar



THE LIBRARY AT THE UNIVERSITY OF TORONTO



Courtesy C. P. R.

PROVINCIAL PARLIAMENT BUILDING, TORONTO, ONT., CANADA

construction. This committee reports directly to the Prime Minister and the Cabinet.

Conservation of Materials to Be Discussed

Conservation of materials will be the topic for discussion on Friday morning, October 1. This will include a description of the steps taken to achieve conservation through modification of design and substitution of less critical materials. Also there will be a discussion on the relative merits of different kinds of fabrication—forging versus casting versus welding. The American speaker will be Howard Coonley, chairman of the Conservation Division of the War Production Board, Washington, D. C. Again it is not possible to give the name of the Canadian speaker on this subject but a man of equal importance in Canada has the matter under consideration.

Manpower Utilization

The Friday luncheon speaker will be a Canadian engineer prominent in the organization of war production. Manpower utilization will be the subject for the Friday afternoon session with particular reference to the steps taken by industry and government to establish policies in training, upgrading, and substitution. Lawrence A. Appley, deputy director, War Manpower Commission, Washington, D. C., will present the point of view of the United States.

Charles E. Wilson to Be Dinner Speaker

Friday evening there will be an informal dinner at which Dr. C. J. Mackenzie, president of the Canadian National Research Council, will serve as toastmaster. Dr. Mackenzie is well known to engineers in both countries because of his outstanding work in the field of research. The principal address following the dinner will be given by Charles E. Wilson, mem. A.S.M.E., executive vice-chairman, War Production Board, Washington, D. C.

Production engineering is the subject for the session on Saturday morning, October 2, with prominent speakers from both Canada and the United States who will summarize the outstanding contributions to production-engineering problems.

Final Meeting Announcements to Be Mailed Early in September

The outline given in the foregoing paragraphs will indicate the importance of this meeting and the outstanding engineers and officials who will be among the speakers. The schedule calls for the issuing of an announcement during the first week in September which will be mailed to the members in the territory contiguous to the meeting place. However, all members are encouraged to advise the Secretary's office at once if they have any thought of attending this meeting even though they may not be positive. The Secretary's office will then be in a position to keep interested members advised of the progress which is being made and any changes which may be instituted because of war contingencies.

Although several other prominent persons have been approached in addition to those mentioned it has not been possible for them to give a definite reply at this time. Indications are, however, that the attractiveness of the program will increase rather than otherwise.

HART HOUSE, UNIVERSITY OF TORONTO

A.S.M.E. Calendar

of Coming Meetings

September 30–October 2, 1943
Joint meeting of the A.S.M.E. with The Engineering Institute of Canada
Toronto, Ontario, Canada

October 28–29, 1943
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

November 29–December 3, 1943
A.S.M.E. Annual Meeting
New York, N. Y.

April 3–5, 1944
A.S.M.E. Spring Meeting
Birmingham, Ala.

June 19–22, 1944
A.S.M.E. Semi-Annual Meeting
Pittsburgh, Pa.

(For coming meetings of other organizations see page 30 of the advertising section of this issue)

D. S. Jacobus Reviews Work of A.S.M.E. Boiler Code Committee

Safety Element Rigidly Adhered to by Committee

AT a meeting of the National Board of Boiler and Pressure Vessel Inspectors held at New Orleans, La., in May, Dr. D. S. Jacobus, for many years chairman of the Boiler Code Committee of The American Society of Mechanical Engineers, reviewed some of the work of that committee. Portions of Dr. Jacobus' address follow:

At your past meetings I have told what is being done by the Boiler Code Committee. As you know, the committee has been urged to issue a number of interpretations to meet the war emergency. Every rule the committee has sanctioned is safe. The Committee would not live up to the primary object for which it was appointed if the safety element were not always kept in mind and rigidly adhered to.

Proposed Revision of Section VIII

One of the major considerations now before the committee is the Proposed Revision of Section VIII of the Code, and the special committee considering this revision has spent a great deal of time on this work. At its last meeting, which ran continuously for three days, comments received from manufacturers, users, inspectors, and other interested parties on the preliminary draft, dated January, 1942, were considered. It was agreed to simplify the rules in the body of the Code in so far as practicable and to provide an appendix containing mandatory rules for the guidance of designers and manufacturers covering such parts as follow:

(*a*) Bolted flanged connections
(*b*) Reinforcements
(*c*) Alternate forms of simplified formulas given in the body of the Code.

The general idea is to simplify the body of the Code for the use of the inspectors and to make the manufacturers responsible for following the rules for design contained in the mandatory appendix through signing the manufacturers' data reports and through the use of their code symbol stamps. This will result in greatly simplifying the body of the Code while preserving the safety of the Code as a whole.

Hard Sledding in Early Days

The Committee had hard sledding in the early days and it was questionable whether it might not be abandoned by the Society. At a crucial time Mr. Henry Hess, who was a member of the Council, proposed that the committee secure the co-operation of all interested parties in formulating the Code. An advisory committee was appointed of eighteen members representing industries and professions having to do with boilers. After the first Code was issued in 1914, this advisory committee was merged with the original Boiler Code Committee and its members acted in their individual capacities as members of the committee and not as representatives of any particular group.

The Committee owes its success to more than this. After my resignation as chairman, I was asked a number of times by officers of the Society what I considered the principal reason for the success of the Code. I said it was the close co-operation with your group and the adherence to the principle of unanimous agreement on all actions. These were well understood in the early days but in the rush of recent events brought on by the war there were some who felt that the proceedings which required unanimous action might be unduly restrictive.

Purpose and Methods of Functioning

The purpose and methods of functioning of the Boiler Code Committee which are still followed were set forth in a paper prepared by Dr. F. R. Low, its chairman, and by me, its vice-chairman, which was presented at the World Engineering Congress in Tokyo in 1929. This paper was checked and approved by a number of the members of the committee. It read in part as follows:

The interpretations, as well as the proposed revisions, are submitted in typewritten form to the members of the Conference Committee as well as to the members of the Boiler Code Committee, and the members of the Conference Committee are requested to submit their views either in favor of or against the actions. A single adverse opinion respecting any one of the interpretations or the proposed revisions results in referring it back to the Committee in the same way as where an adverse criticism is received from a member of the Boiler Code Committee.

The American Standards Association came into being after the Boiler Code Committee was established and the Society considered placing the Boiler Code Committee under its jurisdiction. That it was clearly understood that your group had a voice in the Code was shown when this proposal was considered at one of the meetings of the Boiler Code Committee. All of the members of your group present objected strenuously and one said, "We know just where we stand under the present conditions where any one of us can hold up his hand and stop an action taken at a meeting, but where might we be if we had to follow some other procedure?"

Suggestions Will Receive Attention

If, therefore, you will review the proposed interpretations and revisions which are regularly sent you from the office of the Boiler Code Committee and submit your views in writing to the secretary of the committee, you can rest assured that any suggestions or criticisms will receive every attention.

All Work Submitted to A.S.M.E. Council

As was brought out in the paper presented at the World Engineering Congress, all work done by the committee is submitted to the Council of the A.S.M.E. before it is released. The states and municipalities that have adopted the Code have done so with the knowledge that it has the endorsement of a powerful engineering society and the fact that a member of the Conference Committee can have a proposed action withheld has added to the confidence in the Code.

A.S.M.E. Oil-Engine Power Cost Report Now Available

EXECUTIVES and engineers concerned with the problem of economic power supply for industrial plants will find authoritative and useful data on cost of operation of Diesel engines in the Report on Oil-Engine Power Cost for 1941. This report, compiled annually since 1929 by a subcommittee of the Oil and Gas Power Division of The American Society of Mechanical Engineers, has become internationally known as an impartial and accurate source of information on such matters as fuel and lubricating-oil consumption, and cost of supplies, maintenance, repairs, and supervision.

Covered by the report are 151 actual plants for which complete operating-cost figures are given, with data on type of plant and equipment and conditions of operation. In addition, production costs for 140 plants reporting for two or more years are included; 100 of these plants have reported for five or more years and 38 for ten or more. These long-term comparative costs offer an excellent picture of true average costs, usefully supplementing the figures for 1941.

Owners and operators of truck and bus fleets will find equally useful information in a section devoted to costs of Diesel engines in automotive service. This section, representing the third annual survey, presents vehicle and engine data and costs received from 15 owners and operators of Diesel-powered busses and trucks, 762 vehicles in all.

Lincoln Award Studies to Appear in Book Form

THE James F. Lincoln Arc Welding Foundation has announced that it plans to issue a 1200-page book containing 98 of the outstanding award studies submitted in its 1940–1942 Industrial Progress Award Program. The contents of the book, which is to be entitled "Studies in Arc Welding," are to be arranged in nine sections: Automotive (11 chapters), aircraft (7 chapters), railroad (9 chapters), watercraft (4 chapters), structural (11 chapters), furniture and fixtures (6 chapters), commercial welding (4 chapters), containers (6 chapters), and machinery (40 chapters).

A.S.M.E. Juniors Appointed to Committees

AT the recommendation of the Junior Group of the A.S.M.E. Metropolitan Section and of the committees on which they will serve, President H. V. Coes has appointed Irving Taylor to the Committee on Meetings and Program, and Harold Herkimer to the Committee on Publications, for terms of two years as junior representatives.

Professor Allcut Receives Medal at Toronto

The University of Toronto advises us that E. A. Allcut, Mem. A.S.M.E. and professor of mechanical engineering at the University, was awarded the Plummer medal for 1942 by The Engineering Institute of Canada.

President's Page

War Production Clinics

OUR Society, at the request of the War Production Board, initiated and sponsored on May 5, 1942, at Dayton, Ohio, the first War Production Clinic. Subsequently, the Society entered into a contract with the War Production Board to conduct a series of similar clinics in certain industrial centers of the nation.

These clinics, as many of you know, are organized around a panel of competent speakers, and they have as their objective the solving of industrial production problems, the exchange of ideas on production methods, and the determination of effective means of increasing production. That these clinics have been useful in our war effort is attested to by the fact that in 1943 the War Production Board asked to have the contract extended.

Clinics have been held in the following cities:

Atlanta, Ga.
Birmingham, Ala.
Boston, Mass.
Bridgeport, Conn.
Buffalo, N. Y.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Dallas, Texas
Davenport, Iowa
Dayton, Ohio
Hartford, Conn.
Indianapolis, Ind.
Kansas City, Mo.
Kingsport, Tenn.
Los Angeles, Calif.
Louisville, Ky.
Newark, N. J.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Peoria, Ill.
Philadelphia, Pa.
Providence, R. I.
Rochester, N. Y.
Schenectady, N. Y.
Seattle, Wash.

It has been proposed that clinics now be repeated in each of the cities already mentioned and that additional clinics be held in each of the following cities:

Akron, Ohio
Baltimore, Md.
Columbus, Ohio
Denver, Col.
Detroit, Mich.
Fort Wayne, Ind.
Grand Rapids, Mich.
Knoxville, Tenn.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Pittsburgh, Pa.
Portland, Ore.
Rockford, Ill.
San Francisco, Calif.
Spokane, Wash.
Springfield, Mass.
Springfield, Vt.
St. Louis, Mo.
Toledo, Ohio
Waterbury, Conn.
Worcester, Mass.

The War Production Board, its regional offices, the armed services, industry, and the following societies have all co-operated wholeheartedly in this endeavor:

American Association of Engineers
American Chemical Society
American Electroplaters Society
American Foundrymen's Association
American Industrial Radium and X-Ray Society, Inc.
American Institute of Architects
American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Civil Engineers
American Society of Heating and Ventilating Engineers
American Society for Metals
American Society of Refrigerating Engineers
American Society of Safety Engineers
American Society for Testing Materials
American Society of Tool Engineers
American Welding Society
Army Ordnance Association
Association of Iron and Steel Engineers
Electro-Chemical Society
Electrical Maintenance Engineers Association
Illuminating Engineering Society
Industrial Management Society
Institute of Radio Engineers
National Association of Power Engineers
Society of American Military Engineers
Society of Automotive Engineers
Society of Plastics Engineers

(Continued on the following page)

President's Page (*Continued*)

I would like to take this opportunity publicly to thank all these participants.

In addition I wish to thank several A.S.M.E. members who have given unsparingly of their time, energy, and resources in promoting, organizing, and directing these clinics.

Col. James L. Walsh, a distinguished reserve officer of the United States Army, one of the founders of the Army Ordnance Association, and organizer of the First Peacetime Ordnance District, which included the metropolitan New York area, and chairman of the Society's War Production Committee, has traveled all over the country, and is continuing to do so, in behalf of these clinics and other Society matters. His unselfish and inspiring devotion to the cause has been invaluable in these respects.

Your presidential nominee, Robert M. Gates, devoted his efforts and organizing ability in the initial stages of this movement with notable success.

P. T. Onderdonk, who has been assigned by the War Production Board, has been charged with the responsibility of organizing the clinics and assisting the local groups who sponsor them. He too has done notable work in extending the clinics and piling up the continued record of successes.

Col. C. E. Davies, Ernest Hartford, and George A. Stetson of the staff, have worked quietly and most effectively behind the lines in ironing out difficulties, procuring co-operation and publicly facilitating the efforts of all concerned.

I desire to pay tribute publicly at this time to our own local sections' executive committees on which has fallen the brunt of the burden of these clinics. It is a job of no mean proportions to organize clinics which result in attendance as high as 3000 as was the case in Los Angeles, Chicago, and other industrial centers, and it is my privilege to thank all of them for all the members of the A.S.M.E., sister societies, and organizations that have assisted in making these clinics possible.

Finally, I wish to take this opportunity to thank the Chairman of the War Production Board, Mr. Donald M. Nelson, for his faith in, encouragement of, and assistance in, this movement.

I am proud of what these men in our Society have accomplished by this contribution to the war effort and I want each member of the Society to know this.

(*Signed*) HAROLD V. COES, *President, A.S.M.E.*

1943 Joint A.I.M.E.-A.S.M.E. Fuels Meeting

To Be Held at William Penn Hotel, Pittsburgh, Pa., Oct. 28-29

TENTATIVE plans for the 1943 joint Fuels Meeting of the Fuels Division, The American Society of Mechanical Engineers, and the Coal Division, the American Institute of Mining and Metallurgical Engineers, to be held at the William Penn Hotel, Pittsburgh, Pa., Oct. 28-29, have been announced by T. E. Purcell, vice-president A.S.M.E., serving as general chairman of the local joint committee.

Registration will begin at 9 a.m. on October 28, followed at 9:45 by an address of welcome by the Honorable Cornelius Scully, Mayor of Pittsburgh.

A luncheon will be held on Thursday noon at which H. F. Hebley, member A.S.M.E., of the Pittsburgh Coal Company, will speak on Australia.

At the banquet on Thursday evening Mr. Purcell will act as toastmaster and it is expected that Lieut. Col. Nathaniel F. Silsbee, who created such enthusiasm by his addresses on global warfare at the A.S.M.E. Spring Meeting, Davenport, Ia., and at other A.S.M.E. meetings, will be the principal speaker.

The presentation of the Percy Nicholls Award for 1943, to Henry Kreisinger, will be an impressive feature of the dinner.

Technical sessions are scheduled for the mornings and afternoons of the two-day meeting.

It is expected that the complete program of the meeting will be printed in the October issue of MECHANICAL ENGINEERING. Members of the Society who are interested in the meeting should address Headquarters for further information.

Kreisinger to Receive Percy Nicholls Award

IT HAS been announced that the Percy Nicholls Award for 1943 is to be given to Henry Kreisinger, mem. A.S.M.E., manager of the development and research department, Combustion Engineering Co., Inc., New York, N. Y.

The Percy Nicholls Award, which was instituted by the Fuels Division of The American Society of Mechanical Engineers and the Coal Division of the American Institute of Mining and Metallurgical Engineers, is awarded "for notable scientific or industrial achievement in the field of solid fuels."

Presentation of the award will be made at the banquet, October 28, during the Seventh Annual Joint A.S.M.E.-A.I.M.E. Fuels Meeting, Pittsburgh, Pa.

The first recipient of the Percy Nicholls Award was E. G. Bailey, member A.S.M.E., vice-president, The Babcock and Wilcox Co., New York, N. Y.

A.S.T.M. Elects Officers

THE American Society for Testing Materials has announced the election of officers for 1943-1944. Dean Harvey, materials engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., became president, for a term of one year, and J. R. Townsend, materials standards engineer, Bell Telephone Laboratories, Inc., New York, N. Y., vice-president for a two-year term. Members of the executive committee (two-year terms) are: T. A. Boyd, W. H. Finkeldey, E. W. McMullen, E. O. Rhodes, and F. G. Tatnall.

The 1943 A.S.T.M. Dudley medal was awarded to Walter Bonsack, chief metallurgist and director of research laboratories, The National Smelting Company, Cleveland, Ohio, for his paper, "Discussion of the Effect of Minor Alloying Elements on Aluminum Casting Alloys."

L. H. Fry Named Research Director of Locomotive Institute

LAWFORD H. FRY, member A.S.M.E., Worcester Reed Warner Medalist, 1938, and railway engineer with the Edgewater Steel Company, has been named director of research of the Locomotive Institute.

Mr. Fry will be located at the offices of the Institute, 60 East 42nd St., New York, N. Y.

Among the Local Sections

War Production Conference Held at Yale University

Over 300 Attend Meeting Held at Strathcona Hall

ON February 24 the War Production Conference covering New Haven, Middlesex, and New London counties in Connecticut, with an attendance of approximately 315 persons, was held at Strathcona Hall, Yale University. H. R. Westcott, was master of ceremonies. Before introducing the speakers, he emphasized the point that now is the time to exchange ideas and pool abilities in order to win the war on the production front.

Major John W. Murphy welcomed the manufacturers and spoke of the need of considering the physical and mental well-being of the workers in planning for increased production. Lieut. Col. L. T. Hapgood complimented the manufacturers on the good work they have been doing and told of the help they have contributed by redesign of material and methods and by planning for the future of the workers. Lieut. Com. H. B. Shepard discussed the successful way in which the many production demands of the Army and Navy are being met. Joseph Smith gave figures on the number of employees that will be required and stated that every available person should be employed.

He made the following suggestions to help supply the needed manpower:

(*a*) Shorten high-school courses by six months to free students
(*b*) Relax retirement-age requirements and call back employees already retired
(*c*) Employ women in greater numbers
(*d*) Employ aliens and negroes
(*e*) Use the manning table and grade employees carefully to utilize the fullest use of their skills
(*f*) Train physically handicapped persons.

There were four Panel Sessions held at this conference.

Panel Session No. 1—Personnel

Prof. Hudson B. Hastings, Yale University, presided as chairman.

The first speaker was A. F. Snyder, personnel superintendent, Winchester Repeating Arms Company, New Haven. He spoke on "Women in Industry." The second speaker, Mrs. Alice Marshall, director of the U. S. Employment Service, New Haven area, added to Mr. Snyder's remarks and brought out the point that it is essential to pay women the same wages paid men in cases where they are doing the same job.

Dr. Howard W. Haggard, professor of applied physiology at Yale University, the third speaker on this panel, spoke on "Nutrition as an Aid to Production." A. E. Whitehill, Training Within Industry, War Manpower Commission, New Haven, described T.W.I. and spoke on "Job Training." He stated that 216 Connecticut concerns have been or are participating in the programs, that 13,000 to 15,000 supervisors have been trained or are now in training, and that 200,000 workers have been exposed to the merits of the training.

The fifth speaker, Prof. Lauren E. Seeley, mem. A.S.M.E., regional director for Connecticut and Rhode Island Engineering, Science, and Management War Training Program, spoke on "Technical and Management Training." He stated that 20 per cent of the students are women and that those attending classes are largely chosen by a training co-ordinator in their own plant or some other representative of management.

Panel Session No. 2—Materials

Charles Hitch, W.P.B. Washington, D. C., explained clearly the "why" of the Controlled Materials Plan, and stated that C.M.P. will apply to Class A products, allocate to schedule, balance requirements and availability, and eliminate tie-ups. Mr. Creighton, substitute for Mr. Anderson, explained the vast amount of time being given to the finding of replacements for critical materials. John Freeman, Jr., American Brass Company, described the very difficult problems of practical nonferrous substitutes. Charles Hardy, Hardy Metallurgical Company, stated that while powder metallurgy is a comparatively new art it has accomplished much for the war effort, although manufacturers in this area are slow to adopt same. One part is being made at the rate of 4000 a minute and die life runs from 250 to 100,000 pieces. Much interest was displayed in Mr. Hardy's production samples.

Panel Session No. 3—Tools

A. A. Merry, production engineer, Pratt and Whitney Aircraft Division, United Aircraft Corporation, Hartford, Conn., spoke on "Education in the Conservation of Perishable Tools." The general course of his talk pertained to the recovery of used cutting tools of high-speed steel.

William Buxbaum, mechanical engineer, Winchester Repeating Arms Company, New Haven, Conn., spoke on "Tools for the Manufacture of Cartridges." He stated that for every million shells produced, about 750 tools are required. As land fighting may become more prevalent it is now reasonable to suppose that we have not yet hit the maximum in production of shells.

V. H. Ericson, technical engineer, Norton Company, Worcester, Mass., spoke on "Grinding Finish on Cutting Tools for Improved Performance."

Panel Session No. 4—Welding

Gustave Walter of the Bigelow Company, New Haven, Conn., was chairman of the panel session on welding.

The first speaker was James Mitchell of the Farrel-Birmingham Company, Derby, Connecticut, who spoke on "Increased Production by Welding of Steel Castings and Plates." The second speaker was A. M. Setapen, Handy and Harmon Company, Bridgeport, Conn., whose subject was "Increase in Production by Silver Brazing." He stated that silver-alloy rods melt between 1175 and 1350 deg. A very clean surface is required and the rod will then run through the entire joint through capillary action.

The third speaker was L. F. Bock, Mem. A.S.M.E., General Electric Company, who discussed "Increased Production by Spot Welding." Mr. Bock had a sample board of actual welded parts made at General Electric and explained the difficulties encountered in welding each one.

The last speaker, H. R. Kruitbesch, Electroloy Company, Bridgeport, Conn., lectured on the subject "Increased Production by Stored-Energy Welding." He stated that a Russian engineer made the initial and best research on

1943 Local Sections Group Conferences

Group	*City*	*Place*	*Date*	*Presiding Officer*
I	Providence	University Club	October 9	F. C. Richardson
II	New York	A.S.M.E. Headquarters	October 13	W. S. Gleeson
III	Ithaca	Willard Straight Hall	October 14	F. S. Erdman
IV	Atlanta	Ansley Hotel	October 19	W. R. Chambers
V	Cincinnati	Herman Schneider Foundation	October 21	R. R. Slaymaker
VI	Chicago	Palmer House	October 27	C. C. Austin
VII	Seattle	Olympic Hotel	October 13	J. G. McGivern
VIII	Dallas	Baker Hotel	October 23	L. J. Cucullu

TIME: 9:30 a.m. for all Conferences except Group II, which will be 5:30 p.m.

stored-energy welding up to as late as 1930. Recent developments have been made mostly in the United States. Stored-energy arc welders are now being developed for the welding of brass and copper sheet, which will revolutionize certain rolling processes now used as standard practice.

Admiral Rosendahl at Akron-Canton Section

On July 2, the Akron-Canton Section held a dinner meeting at the Mayflower Hotel, at which 500 members and guests were present. The guest speakers were Rear Admiral C. E. Rosendahl, U.S.N., and Mr. Harry Blythe, vice-president and general manager of Goodyear Aircraft Corporation. Their subject was "The Present and Future of Heavier- and Ligher-Than Air Craft." Admiral Rosendahl discussed the part that Navy patrol blimps have played in the war effort. He also outlined the tremendous progress that has been made in expanding training facilities, personnel base facilities, and patrol work. Mr. Blythe reviewed advancements in airplane production, paying particular attention to the Navy pursuit ships made by Goodyear Aircraft Company.

Activities of Atlanta Section During Past Year

The Atlanta Section of the A.S.M.E. met on June 14 at which Mr. John M. Rittelmeyer, mem. A.S.M.E., spoke on the activities of the Atlanta Section during the past year. He told of the work this Section did for the scrap-metal drive and the War Production Conference. Mr. John Parker, mem. A.S.M.E., stated that the Section was in good condition financially and that membership had increased approximately 10 per cent since September, 1941. Officers were elected for the 1943-1944 year.

Mr. Stephen C. Hale, mem. A.S.M.E., gave a brief talk on the Aims and Purposes of the A.S.M.E., and outlined the advantages of the organization and the services it renders. Following this talk, a film on the "Sikorsky Helicopter" was shown. Professor Dalton of the Georgia School of Technology spoke on helicopters in general as well as the Sikorsky model.

Southern California Section Hears Prof. W. H. Pickering on Electronics

The Southern California Branch met for dinner on July 22 at the Mary Louise Tea Room to hear Professor Pickering, teacher of radio and electronics at the California Institute of Technology. Professor Pickering has worked with Dr. R. A. Millikan in the field of cosmic rays, and he has made a number of expeditions with Dr. Millikan investigating cosmic rays in various parts of the world. Since World War II his work at the Institute has included work with microwaves. His talk dealt particularly with ultra high frequency and included a demonstration of some ultra-high-frequency phenomena.

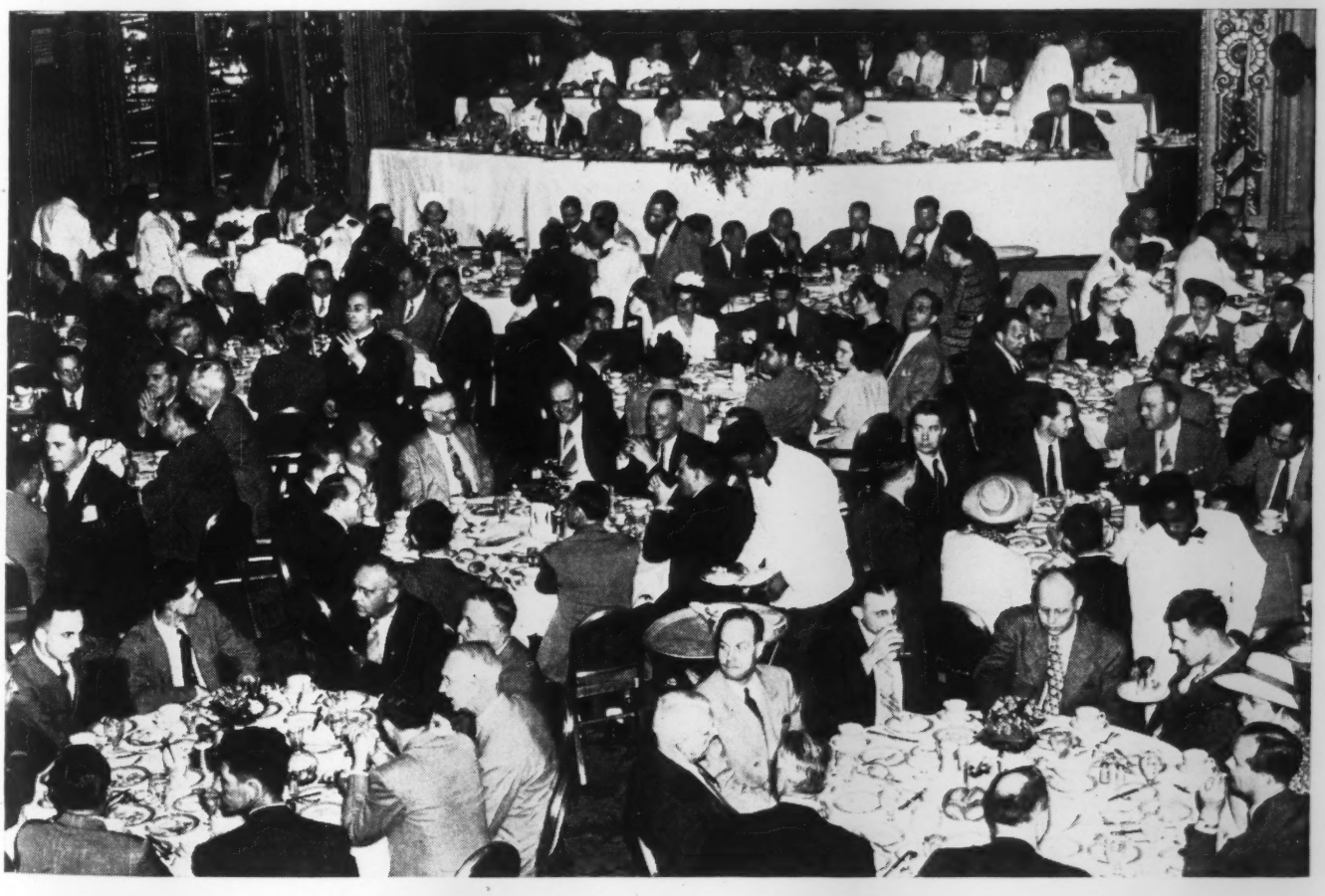
Plans of Metropolitan Junior Group for Coming Season

New officers of the Metropolitan Section Junior Group who took office July 20th are Paul B. Petty, chairman; W. Wiitanen, vice-chairman; and J. J. Jacobs, Jr., secretary-treasurer. At the meeting of the executive and administrative committees held on that date it was announced that Messrs. F. H. Fowler, Jr., F. Gibson, Jr., J. Pollak, and I. West have also been elected as members of the executive committee. Appointments of standing committee chairmen and members, to comprise the new administrative committee, were made as follows: Program, W. Wiitanen; publicity, I. Taylor; membership, H. Herkimer; nominating, J. Jacobs, Jr., I. West, I. Taylor, and R. Frank; study group, J. Taylor and J. Trego.

Any A.S.M.E. Juniors living in or near New York who wish to become better acquainted, or who would like to participate in activities are urged to get in touch with any of the foregoing. A.S.M.E. headquarters will advise as to their business addresses.

For the fall season, the Junior group expects to start with a September 21 meeting at which a speaker from the Eastern Railroads Presidents' Conference will explain what the railroads are doing to help win the war. Then on October 26 they will meet to hear Mr. J. R. Morrill of The Lincoln Electric Co. in Ohio, probably on the subject, "Application of Fusion Welding in Industry."

A joint meeting is planned for November 23 together with the Metropolitan Section



AKRON-CANTON SECTION DINNER MEETING AT MAYFLOWER HOTEL BALL ROOM, AKRON, OHIO, JULY 2, 1943

of the American Foundrymen's Association, to hear R. G. McElwee of the Vanadium Corporation of America, from Detroit. He is to present a paper on "Gray Iron as an Engineering Material." And for December, probably the fourteenth, the Juniors expect to have a speaker on the subject, "Compressed Air in Industry."

Juniors who are working long hours on vital projects in the metropolitan area ought not to neglect these meetings from any feeling that wartime stresses make attendance unnecessary. On the contrary, this is just the time to keep a broad outlook, and to help solve those specialized daily problems by a monthly "refresher" on the general picture. Tentative plans for part of the winter season include a not-too-technical meeting on "Electronics," a possible joint meeting with the Junior Chemical Engineers, and a business meeting at which the Junior advisors on certain "Senior" A.S.M.E. Committees will report.

Colonel Walsh at Oregon Section Explains Logistics

On June 21, the Oregon Section of the A.S.M.E. tendered a dinner to Col. James L. Walsh at the Portland Hotel, Portland, Ore., after which he delivered an address at the auditorium of the Public Service Building. Major General Charles H. Martin, former U. S. congressman and ex-governor of the state of Oregon, introduced Colonel Walsh. Approximately 125 men were in attendance.

The Portland *Oregonian* of June 22 writes as follows on this meeting.

"Logistics," said tall, he-man Colonel James L. Walsh, West Point '09, in a voice that could be heard, "is the job of getting the things to the right people in the right places at the right time."

Colonel Walsh, chairman of the war-production committee of The American Society of Mechanical Engineers, breezed into Portland Monday afternoon, breezed out again a few hours later after speaking on 'Logistics, the Key to Victory." Between answering the telephone, trying to assemble his clothing, getting a bathtub full of water, hunting through his brief case for important papers, making notes for reference when he gets back to New York, replying to questions by the reporter, Walsh was busy. But he didn't stutter. The Colonel said, "The last war was a machine-gun war, but this one is developing into a bombing war; we are using bombs against troops, against supply lines, against railroad trains and power dams, and against almost everything else. If old General Forrest of the confederate army were around today he would say, 'Git thar furstest with the mostest bombs!'"

In his address Monday night Colonel Walsh declared, "The whole result of our war effort can be no greater than the sum of all our individual efforts. Military, naval, and air offensives, all are born in our fields and forests, our mines and mills, our smelters and shipyards, as well as in our drafting rooms and research laboratories, our schools and colleges—and most important of all—in our homes."

Hawaii Holds Two Interesting Meetings

Engineering Association of Hawaii Hears Wm. F. Goldsmith on "Canec"

On May 21 the Engineering Association of Hawaii met to hear Wm. F. Goldsmith discuss "Canec." He stated that the history of insulation board began with the manufacture of "Insulite" in the state of Minnesota. The year 1920 found the Celotex Company manufacturing insulation board from a mixture of bagasse and waste paper. Though Masonite is generally regarded as a hard-board product, the manufacturers do, nevertheless, make an insulation board. There are many other similar boards bearing various trade names. Today, 14 plants manufacture insulation board with a daily capacity of 5 million feet. Hawaii's Canec plant is located at Hilo. It was built in 1932. Bagasse is delivered to the plant from various sugar mills. Cyclone unloaders draw it into storage bins. It is then released into the digester as required.

The process of manufacture is somewhat as follows: First, the material is cooked in a one per cent solution of lime. This darkens and strengthens the fibers. It is then passed through a magnetic field which extracts any iron that may be present. Grinding between two revolving disks is next in order. The resultant pulp then goes to storage. The pulp is drawn from storage as required. It first passes through a vacuum-type 'forming' machine. It is chemically treated to resist water and termites. After this processing, it is passed through two presses. The first press cuts the sheet into approximate lengths and eliminates some of the water. The second press completes the job. The sheets now pass through the drier. After this they are sawn into exact lengths.

Mr. Goldsmith exhibited samples of many different types and sizes of Canec. Besides the more common varieties, he showed: Ivory-finished Canec for greater light-reflecting qualities; a tongue and groove board for inside finish; two-inch refrigeration insulation board; and an asphalt-treated board for weather-resistant outside construction.

Production figures for the year 1943 were given as 72 million feet. The army took 39 million feet of this total. Export trade, which before the war extended to all parts of the world, is now practically out.

Electric Power in Wartime at Hawaii

On June 4, the Engineering Association of Hawaii heard Harry P. Field, fellow member and manager of the commercial department of the Hawaiian Electric Company, speak on "Electric Power in Wartime." The general prediction in Washington in 1941 was that if we went to war there would be a great shortage of power. Because of the foresight and efficiency of the electric-power industry this gloomy prediction has proved false. Since the blackouts have been in effect the residential bill for electricity has been reduced. At the same time, residential consumption for cooking and heating has unexpectedly increased. This is because blackout and curfew have discouraged dining out. More meals are cooked at home. The radio is on almost continuously. Particularly was this true in the early days after Pearl Harbor Heavy usage can run up a consumption of 15 to 25 kwhr in the course of a month. Daylight saving was credited with effecting the greatest economy in the demand on the power industry, as it constitutes a power "shot-in-the-arm" for the diversity factor. Approximately 1,250,000 hp have been released, which has been diverted to war industries.

The speaker also told of a number of important improvements to the commercial world through improved electrical technology. The tin-plating of cans, for instance, is now done electrically. Heretofore, the cans were dipped. Electroplating saves approximately two thirds of the tin. Again, the thickness of rolled steel plate is now electrically controlled to one thousandth of an inch by means of an X-ray and an ionization box.

The electron-microscope is another recent invention. It is ten times as powerful as any microscope hitherto known. It has revolutionized the field of research.

Mr. Field stated that salesmanship in the electrical world is now functioning in reverse. Before the war the keynote of salesmanship was to induce the consumer to use more current. Today, however, he is being sold the idea of energy economy. Effort is also being made to induce the consumer to sell back to the company—or, to his neighbor—electrical equipment for which he has no further use.

With the Student Branches

THE ARKANSAS BRANCH opened the 1943-1944 year with enthusiasm over future plans and activities. Officers and representatives were elected. Because of the number of members, this year each member was given an entire meeting to present his paper. Three technical films were shown—"Thermodynamics," "Problems of Flight," and "Theory of Flight." Prof. F. J. Daasch, mem. A.S.M.E., of the mechanical-engineering department, gave a short talk on the advantages of A.S.M.E. membership.

The CALIFORNIA INSTITUTE OF TECHNOLOGY met on July 14 to elect officers for next year. They are George Shor, chairman; Ross Buchannan, vice chairman; Richard Soike, treasurer; and Jack Kettler, secretary. Prof. R. L. Daugherty, Mem. A.S.M.E., and instructor in hydraulics at the Institute, will replace Prof. W. H. Clapp, Mem. A.S.M.E., who has resigned from the Institute staff as faculty advisor.

The Supercharger at Cooper Union

At COOPER UNION BRANCH a meeting was held on July 27 at which Albert Kushner, a student, lectured on "The Supercharger." On explaining the various types of superchargers, he frequently referred to curves which he had drawn. Supplementing these data with *P-V* diagrams, it became clear that the type most used today is the turbine-driven

DREXEL INSTITUTE OF TECHNOLOGY A.S.M.E. MEMBERSHIP FOR YEAR 1942-1943

one. Concluding with a brief discussion of the supercharger on the P-38 and B-17E, Mr. Kushner answered queries from the members.

Model Airplane Engines at Drexel

DREXEL STUDENT BRANCH met on June 24 for their first meeting of the summer term. A motion was passed to have a picnic and Mechanical Engineers' "Get-together" at the Drexel Lodge. As president Schwartz entered the Navy on July 1, Arthur Watkins was appointed acting president until such time as a new president is elected. L. M. Church of the Carrier Corporation gave an interesting talk on refrigeration and air conditioning illustrated with lantern slides. On July 13 the Branch heard a talk on "Model Airplane Engines," given by Arthur Watkins, a student member. The lecture was illustrated with pictures and miniature models. The theory of combustion, ignition, and carburetion was discussed. A model gas airplane engine was exhibited and the speed determined with a strobotac.

At a meeting of the IOWA BRANCH on June 16, President Perelman introduced Prof. David L. Arm, Mem. A.S.M.E., who outlined the future of A.S.M.E., for the duration of the war. He also explained the relationship of the incoming V-12 Naval Reserve men to the school and to the professional societies. It was suggested that personnel men who come to the school to interview senior engineers be invited to address the student meetings. Don Augustin was appointed head of a committee to arrange a smoker to acquaint the new Navy men with the A.S.M.E. The Branch met again on June 30 at which films on the manufacture of electron tubes and the R.A.F. "Target for Tonight" were shown.

The first meeting of the summer at the MINNESOTA BRANCH held on June 29 featured Charles E. Doell, graduate of the University of Minnesota in civil engineering, assistant superintendent of the Minneapolis Park Board, and an active member of the professional engineering societies of Minnesota. He spoke on "Licensing of Engineers," and his remarks emphasized the importance of legal protection provided by licensing and the necessity for constant improvement and stricter enforcement of licensing laws.

Unique Dance Planned at North Carolina

The NORTH CAROLINA BRANCH held its meeting on July 6, at which time it discussed a dance to be held on July 17 under the sponsorship of the Student Branch for Naval Ensigns taking Diesel-engineering training, and Pratt and Whitney fellowship girls who are all under the supervision of the mechanical-engineering department. The membership of the Branch has been critically damaged by the national emergency. There are twenty members attending summer school, including the secretary and treasurer.

At the first meeting of the summer term on July 1, the NORTH DAKOTA BRANCH elected Norman Mickelson as secretary to replace Louis Blazek who was called to the armed forces. After the business meeting, a film on "The Making of a V-Type Engine," which dealt with production methods at the Ford Motor Company, was shown.

OREGON STUDENT BRANCH at its monthly meeting on June 30 elected new officers because most of the former ones have entered the service of their country. The new chairman is Arthur Bond; vice-chairman, Chester Reed; secretary, Carleton Fanger; treasurer, Ralph Ullman; publicity, Joe Dremer.

Purdue Sees Movies on "PT-18 Trainer" and "The Winged Scourge"

On June 30 the PURDUE STUDENT BRANCH held its regular bimonthly meeting. A new film produced by the Piper Aircraft Company, entitled "The Construction of a Light Airplane," was shown. In addition, a film showing the details of bomber construction was shown. Officers were elected to replace those who did not return for the summer semester, as follows: David M. Badger, secretary-treasurer; M. J. Schocken, vice-chairman; J. Kimbrell, R. C. Perkey, D. Pliske; and Prof. R. W. Leutwiler honorary chairman.

At a meeting on July 14 the Purdue Student Branch numbering 250 members and guests enjoyed the film "PT-18 Trainer." The PT-18 trainer is a low-winged plane used almost exclusively by the U. S. Air Force for training purposes. The film showed steps in the assembly and manufacture of the Ranger engine used in the PT, as well as enumerating some of the tests to which it is subjected. Perhaps the biggest reason why this type of plane is especially suited for primary training, blind and cross-country flying is because the visibility of the pilot is unusually good. Both the instructor and the trainee have a field of vision not found in most types of planes. The second film "The Winged Scourge," Walt Disney's production in technicolor, was also shown. It depicted the poverty and misery caused by the Anopheles mosquito, carrier of malaria, and showed preventive measures which are necessary to eliminate this pest.

The Branch met again on July 28 and sponsored a joint meeting of all the engineering student branches at Purdue. Approximately 200 engineering students attended this meeting to hear an address by Dean Andrey A. Potter, Mem. A.S.M.E., on the subject "The American Patent System." Dean Potter drew much of his material from a pamphlet published as a report by the National Patent Planning Commission, which he, as executive director of the commission, helped prepare. The idea of a patent system was included in the Constitution over one hundred and fifty years ago. Although containing many faults, it is constantly under surveillance by government committees in an effort to improve it. According to Dean Potter, the fact that the United States is recognized as the leading in-

MEMBERS OF THE PURDUE UNIVERSITY BRANCH OF THE A.S.M.E.

dustrial country of the world is due largely to the American patent system.

Tennessee Hears About Rubber and Pumps

At a meeting of the TENNESSEE STUDENT BRANCH on July 1 the members listened to Dr. R. M. Boarts lecture on "Synthetic Rubber." He stated that the rubber situation was very serious at the beginning of the present war, but through new developments in the synthetic field, conditions have been definitely improved. The importance of reclaimed rubber was stressed. Dr. Boarts indicated that synthetic rubber presents a political as well as an economic influence on the war's outcome.

On July 15 the UNIVERSITY of TENNESSEE BRANCH met and plans were presented and approved for a party on July 23. Student speaker Harold G. Warren spoke on the subject "The Internal-Combustion Pump." Mr. Warren brought out the fact that this pump was originated when a search was being made for a prime mover lacking the inherent difficulties presented by the steam and gasoline engines. He gave a detailed description of the pump and its functions, accompanied by illustrations. The development of the pump from the original to the present form was traced and a comparison made between this and other types of pumps. Prof. W. W. Thomas, Jun. A.S.M.E., read a notice from A.S.M.E. headquarters explaining the new student membership plan.

The first meeting of the new session of the VIRGINIA BRANCH was held on July 20. A program committee was elected. Those chosen were: Emerson W. Smith, chairman; John C. Whitmore, Wm. W. Willoughby, and Irvin M. Eskin. Suggestions were made for coming programs and perhaps one of the most interesting suggestions submitted was an idea for a quiz program in which the students will quiz professors instead of professors quizzing students.

WASHINGTON UNIVERSITY BRANCH, St. Louis, Mo., held its meeting on June 16 for the purpose of electing new officers. They are: Alvin Holstein, president; Roy A. Lieder, vice-president; Fred M. Reitz, secretary; Wm. F. Doherty, treasurer; Yoshio Matsumoto, sergeant at arms. This Branch met again on June 23 and plans were made for a picnic on July 11. Hereafter, a roll-call will be made at each meeting and a penalty of 5 cents will be imposed for the first absence and 10 cents for the second absence, and so on. If penalty assessments are not paid the member will be considered a nonmember at social affairs and will be required to pay nonmember charges.

The WEST VIRGINIA BRANCH held several meetings in June. On June 14 a general engineering society meeting was held in the Mineral Industries auditorium. New officers were elected for the ensuing year. On June 21 they met to hear papers delivered by G. Arnold on "Glass Gages;" F. Mumma on "Copper-plated Timber;" and J. Nunley on "Centrifugally Cast Pipe." This Branch met again on June 29 at which four interesting talks were delivered. These were: "Washing of Coal," by R. Fisher; "Airdromes Overseas," by J. Murray; "Rebuilding Old Machine Tools," by P. Muffly, and "Supervision," by J. Rowe.

WYOMING STUDENT BRANCH met on June 15 to view a sound movie on "Steam Turbines" furnished by the Allis Chalmers Company. About 30 men from the Public Service Company enjoyed watching this film.

Problems in Which Army Is Interested

Suggestions to Be Sent to National Inventors Council

THE National Inventors Council has secured the consent of the Army to the release of a list of some of the problems in which the Army is interested. A practical and effective solution of any of them will be a real contribution to the war effort. Actual war experience has shown the need of various devices or methods not practically available, and has also shown the need or the desirability of substitutes or alternatives for devices and methods already in our possession.

While information of the needs of the Army has only been given to agencies officially authorized to receive and use it, such a list has not heretofore been released since it might give information of what we possess or do not possess. The present list is not of this character and is being released to appropriate professional societies and research organizations in order that it may be passed along to their membership. Additional lists may be released in the future.

Suggestions on any of these problems should be submitted to the National Inventors Council, Room 1313, Commerce Building, Washington, D. C., and should comprise a clear description of the proposal with such sketches or drawings as may be necessary.

1 A method of removing the tetraethyl lead from leaded gasoline to make it usable in stoves, in lanterns, and in small engines.

2 An inexpensive metal suitable for Quartermaster tableware; one having requisite strength, freedom from corrosion by food acids or alkalies; durability and attractiveness.

3 Suitable substitute for rubber for insulating wire; should be flexible and durable.

4 Detectors of enemy personnel who may be approaching (unseen) on jungle trails or fences or similar barriers.

5 Sonic or supersonic means or methods of signaling in the field.

6 Improved means or methods of signaling the identification of ground troops to friendly airplanes and vice versa.

7 Improved traction devices for wheeled vehicles of all types. *Note:* Present chains and other devices are cumbersome, inconvenient to apply and remove, and lack sufficient traction.

8 Tracks for tractors and other motorized equipment which will operate efficiently in snow and extreme cold.

9 Better air cleaners for use on tank engines and the like; more effective than present cleaners and requiring less maintenance.

10 Methods of quick-action waterproofing for enabling vehicles to ford water several feet deep without stalling engines.

(*Continued at top of next column*)

11 A Storage battery not adversely affected by very low temperatures.

12 The detector and method of locating nonmetallic land mines.

13 Equipment or methods for removing land mines rapidly from mine fields without injury to equipment or personnel.

14 Methods of rustproofing ferrous metals, which are more durable than present methods, such as bonderizing, etc.

15 Absorbents for carbon monoxide or catalysts or other means for oxidation of this gas to render it noninjurious to personnel.

16 Means of defeating darkness to permit vision at night without aid of visible reflected light. *Note:* Probably involves an apparatus to translate infrared rays to visible light.

17 Means of long-distance communication outside the present scope of radio and not restricted by line-of-sight projection.

18 Searchlights which may afford ready means for spreading the beam from narrow high intensity to 15 deg of greatest intensity practicable.

19 A simple nontoxic process for darkening aluminum and other metals; to make them nonreflectant to light.

20 Methods of sabotage by friendly inhabitants within occupied areas.

Spot- and Seam-Welding Data for Low-Carbon Steels

THE American Welding Society has recently approved and published a bulletin "Recommended Practices for the Spot and Seam Welding of Low Carbon Steel." The data contained in this bulletin has been compiled by canvassing approximately 60 fabricators of mild steel structures and resistance-welding-equipment manufacturers and is intended to meet the needs of the U. S. Navy and War Departments and those in industry engaged in the production of war matériel. The work was initiated by the Resistance Welding Research Committee of the Welding Research Council and has been approved by the Resistance Welding Standards Committee of the American Welding Society.

The bulletin is composed essentially of two charts—one each for spot and seam welding together with an explanation for their use. For example, after the metal gage is determined, the welding electrode or roll is selected, the pressure adjusted, and the weld time is set and a pull test made. This is the order in which the data appear from left to right on the charts.

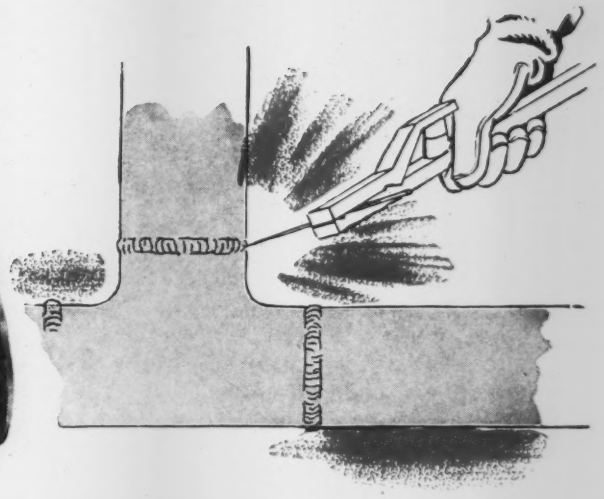
This bulletin represents the best information available at this time on the spot and seam welding of low-carbon steel and is therefore recommended as standard practice during the war emergency. Copies may be obtained from the American Welding Society, 33 West 39th Street, New York, N. Y.

A.S.H.V.E. to Celebrate Fiftieth Anniversary

THE American Society of Heating and Ventilating Engineers has announced that it will hold its Fiftieth Anniversary meeting in New York, N. Y., Jan. 31–Feb. 2, 1944. The New York chapter of the society will be hosts for the occasion.

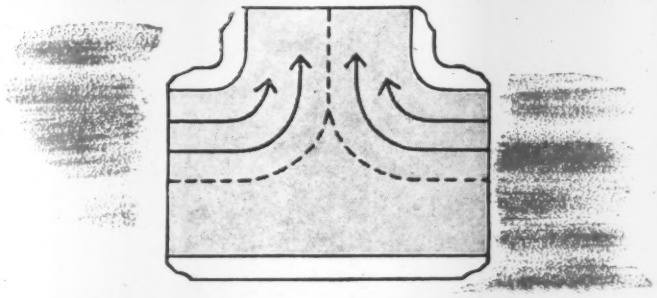
(*A.S.M.E. News continued on page 694*)

How TUBE-TURN welding tees improve piping construction



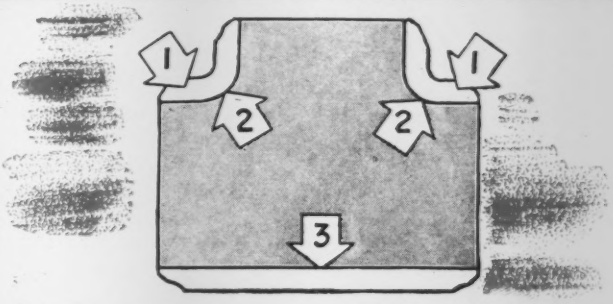
LONGER OUTLETS SPEED WELDING

More room for easier manipulation of rod means faster welding and better, sounder welds.



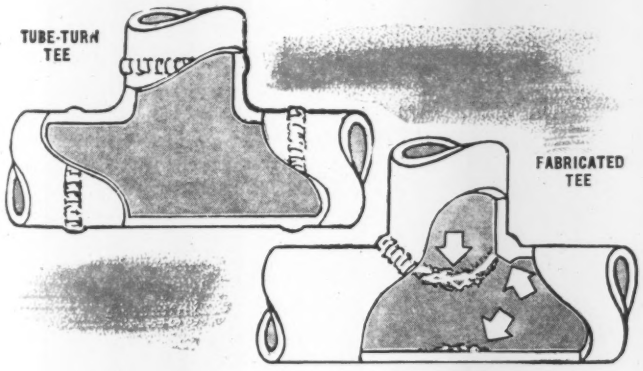
SMOOTH FLOW, LESS PRESSURE LOSS

Smooth inner walls assure even flow and reduce wear. Rounded inside crotch reduces pressure loss.



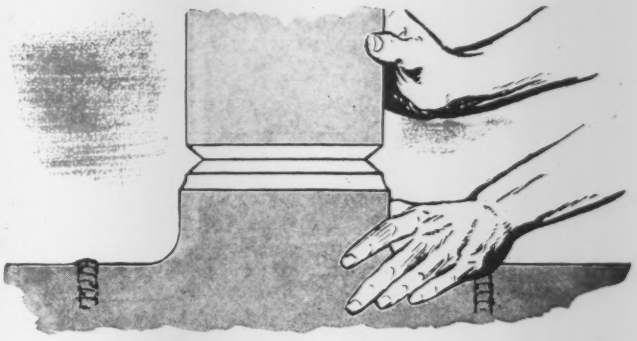
EXTRA STRENGTH AT STRAIN POINTS

Added thickness at top of run (1), crotch (2) and bottom (3) strengthens points of highest stress.



NO FABRICATION FAULTS

Fabricated tees often have jagged corners, crude welds, and slag. Tube-Turn Tees eliminate these.



FASTER, EASIER ALIGNING

Accurate bevels, plus I.D. and O.D. that exactly match the pipe, make aligning simple and speedy.

TUBE-TURN
TRADE MARK

TUBE TURNS (Inc.) Louisville, Ky. Branch offices: New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Houston, Los Angeles. *Distributors in principal cities.*

NO. 8 OF A SERIES
HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

The FIRST WELDING FITTINGS 1ST AND STILL THE BEST

Welding Fittings and Flanges

War Shipping Administration Needs Engineers With Sea Experience

HOW many mechanical engineers who have had experience at sea are now employed ashore is something the Recruitment and Manning Organization of the War Shipping Administration would like to know. A critical need for such men exists right now in the Merchant Marine according to Marshall E. Dimock, Assistant Deputy Administrator of the War Shipping Administration in charge of Recruitment and Manning.

The ever-mounting tempo of our shipbuilding program to meet the requirements of newly opened battle fronts, together with successes in combating the U-boat peril, have created an unprecedented demand for mercantile manpower. This demand is particularly great for First, Second, and Third Engineers.

To illustrate the most recent example of the tasks faced and met by the engineering personnel of the Merchant Marine, the successful invasion of Sicily is cited. Approximately 1000 of the 2000 ships engaged were merchant ships, manned by 4000 licensed engineers.

As new battle fronts are opened up in Europe and the Pacific the demand for licensed engineers will increase. That is why the Recruitment and Manning Organization of the War Shipping Administration is now engaged in a concerted drive to bring back to sea mechanical engineers with previous sea experience now engaged in shore industry. Men who have kept their former sea licenses current should get in touch immediately with the local office of the United States Employment Service or the port representative of the Recruitment and Manning Organization in the nearest seaport to them, or wire or write directly to the offices of the Recruitment and Manning Organization of the War Shipping Administration in Washington. Men who have not kept their sea licenses current should follow the same procedure and they will be referred to the Training Organization of the War Shipping Administration. Such men will be sent to one of the centers where refresher courses in their former sea duties will be given them preparatory to going to sea. At the training centers these men will review the fundamentals of the boilers, engines, turbines, and auxiliaries of the types of ships on which they will sail.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to key numbers and mailed to New York office.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, 30, with broad experience in manufacturing, machine and steel-fabrication shop in executive capacity covering all phases of administrative and technical functions. Desires position with first-class manufacturing firm in solid industry which offers postwar security. Present income, $8000 year. Deferred. Me-812.

POSITIONS AVAILABLE

ENGINEERS. (*a*) Magnesium foundry superintendent experienced in magnesium or aluminum sand castings. Salary open. Ohio. (*b*) Chief metallurgist for magnesium sand casting foundry. Full metallurgical control of sand, metal, heat-treating, and all processes. Salary open. Ohio. W-1280CD.

ENGINEERING ACCOUNTANT to plan and operate all controls, time, materials, schedules, and rate-setting unit costs. Company makes magnesium castings. Salary open. Ohio. W-1754CD.

DRAFTSMAN-JUNIOR ENGINEER with some mechanical-engineering schooling. Must be trained and experienced professional draftsman. Primary duties will be draftsmanship, but must have potentialities for more responsible work. Should show samples of draftsmanship. New York, N. Y. W-2507.

TOOL ENGINEER AND DESIGNER with thorough knowledge of carboloy tools and special precision tool machinery. $7000–$8000 a year. Pennsylvania. W-2528.

ENGINEERS. (*a*) Service engineers in charge of inspection lines. Need not be graduate engineers but must have some practical experience in mechanical trades, i.e., automobile Diesel engines. About $5000 a year. (*b*) Assistants to these who also have mechanical turn of mind, to act as group leaders or foremen on inspection. $3380–$3800 a year. New York State. W-2539.

ASSISTANT SUPERINTENDENT, 30–50, preferably graduate mechanical or chemical engineer to take charge of and route production through plant. Must have previous experience in paint or ink industry. $4500–$5000 a year. New York, N. Y. W-2544.

ENGINEERS. (*a*) Chief engineer in charge of design of process equipment used in chemical, petroleum, and similar fields. $10,000 a year. (*b*) Pressure-vessel engineer with background in this field in chemical industry. About $6000 a year. Delaware. (*c*) Sales engineers to sell boilers and pressure or process vessels. About $7500 a year plus commission. New York and Philadelphia. W-2562.

ENGINEERS. (*a*) Chief inspector on precision machine parts, also tool and gage. About $5000 a year. (*b*) Chief expediter experienced in subcontracting and processing of machined precision metal parts. $4500 a year. (*c*) Assistant expediters also. $3000 a year. New York, N. Y. W-2566.

ESTIMATORS. Prefer graduate mechanical or electrical engineers. Must be able to take off mechanical or electrical quantities from prints. Make up complete bills of materials without checking. About $4200 a year. Maryland. W-2581.

WAGE-INCENTIVE ENGINEERS capable of determining what incentive plans are best suited for installation, make necessary time studies; install procedures for carrying out plan. Some traveling. Pennsylvania. W-2585.

DIE-CAST MOLD ENGINEER, 35–50, with extensive experience as die cast mold designer with following background—tool making, some drafting work, tool and die designing, and practical experience in designing and operation of dies and, if possible, die-cast molds. New Jersey. W-2592.

ENGINEERS. (*a*) Chief draftsman for a large research and development department of metal manufacturing company. Must be able to lay out new processes and materials in conjunction with production departments. About $6000 a year. (*b*) Mechanical, chemical and hydraulic engineer for development work on war and postwar products. Some background in automotive, plastic, plywood, or synthetic-rubber industries desirable. Prefer younger men. $4500–$6000 a year. Northern New Jersey. W-2594.

ENGINEERS, mechanical graduates, who have specialized in design and development work and who are qualified by training and experience to undertake design/redesign, as project engineers, of wide variety of unusual mechanical developments. About $5000 a year. New York and Pacific Coast. W-2598.

ENGINEERS. (*a*) Mechanical engineer designer for power-station design, underground steam distribution, and some heating and ventilating design for a new large construction project. $5720 a year. (*b*) Mechanical draftsmen experienced in layout steam, power plant, heating, ventilating, and machine layout, $4160 a year. (*c*) Structural designer experienced in steel and concrete, particularly industrial or power plant work. $4600 year. (*d*) Architectural draftsmen as above. $4160 a year. Maryland. W-2602.

ENGINEERS, graduate mechanical, with at least one year's experience in steam power plant. Will train to familiarize himself with company equipment; then in engineering department; then will break in on inspection work in field, and finally will supervise installations. Salary open. Considerable traveling. Pennsylvania. W-2608.

MECHANICAL ENGINEERS, experienced or recent graduates, who are technically proficient for engineering and mechanical development work. Must be graduates. Work

(*A.S.M.E. News continued on page 696*)

[1] All men listed hold some form of A.S.M.E. membership.

THERMEX HIGH FREQUENCY HEATING FOR BONDING OR HEAT PROCESSING NON-CONDUCTING MATERIALS MAY BE THE ANSWER

Submit your problem to Girdler Application Engineering Service

Thermex will supply the *heat* and Girdler engineers will supply the *know how* (based on experience) that will help you make the best utilization of Thermex high frequency heating equipment for non-conducting materials.

The number of production operations to which Thermex high frequency heating may be applied are limitless. You may have some jobs that can be done *better, quicker and perhaps cheaper* by Thermex.

Let us study them with you. We suggest that you submit samples of your product and describe your heating problem. Girdler high frequency application engineers will make thorough tests and send you a report for comparison with your present method. We will welcome your inquiry, no matter how difficult your heat processing operation may be. There is no obligation.

The No. 15 Thermex illustrated at the right is one of several standard units available. The simplified diagram illustrates how practically any non-conducting material can be heated by means of top and bottom or center electrodes.

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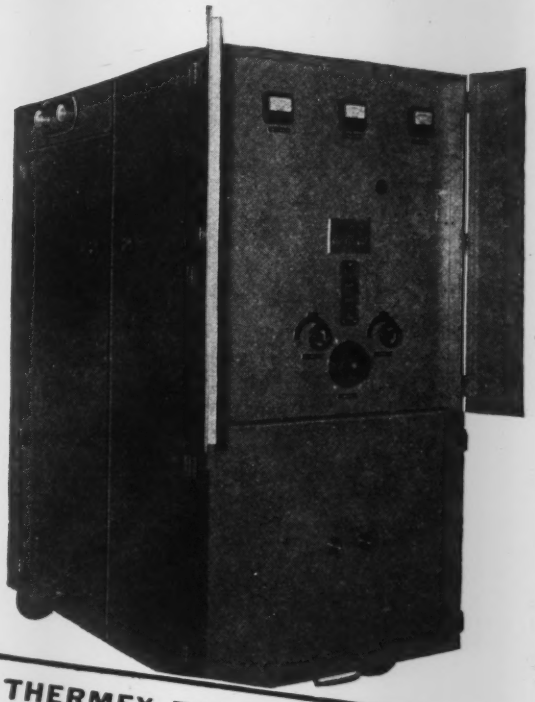
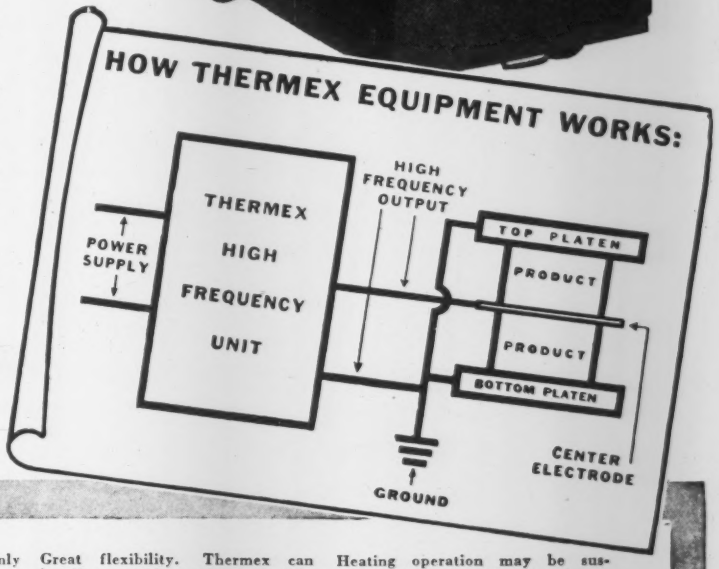
Write for illustrated Thermex booklet describing many phases of high frequency, electrostatic heating.

The GIRDLER CORPORATION

Thermex Division **Louisville, Kentucky**





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Absolutely *uniform* heating means *improved* quality of product.
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Chemical contamination is completely avoided.
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Wide range of sizes for *all* requirements.